FISCAL YEAR 1986 DEPARTMENT OF ENERGY AUTHORIZATION

(Conservation and Renewable Energy)

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
ENERGY DEVELOPMENT AND APPLICATIONS

OF THE

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SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

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CONTENTS

WITNESSES

March 5, 1985:

William Patrick Collins, Under Secretary, U.S. Department of Energy, Washington, DC; accompanied by Donna Fitzpatrick, Principal Deputy Assistant Secretary for Conservation and Renewable Energy; Alan Streb, Deputy Assistant Secretary for Conservation; Dr. Robert San Martin, Deputy Assistant Secretary for Renewable Energy; and Frank Stewart, Director, Office of State and Local Assistance Programs .... Page 4
  Prepared statement 8
  Discussion 43
Dr. Harold M. Hubbard, director, Solar Energy Research Institute, Golden, CO 57
  Prepared statement 60
  Discussion 75
  Questions and answers for the record 79

Panel 1: Photovoltaics and Renewables

Dr. Henry Ehrenreich, Clowes Professor of Science and director, Materials Research Laboratory, Harvard University, Cambridge, MA 81
  Prepared statement 84
Mark W. Anderson, photovoltaic project manager, Sacramento Municipal Utility District, Sacramento, CA 89
  Prepared statement 98
Dr. Donald Klass, president, Biomass Energy Research Association, Washington, DC 104
  Prepared statement 106
Dr. Michael E. Berger, deputy associate director, Alternative Energy Sources, Los Alamos National Laboratory, Los Alamos, NM 115
  Prepared statement 118
Questions and answers for the record:
  Dr. Ehrenreich 128
  Mr. Anderson 131
  Dr. Berger 138

Panel 2: Electric Utilities—Technologies for the 1990's

Dr. Peter D. Blair, project director, Energy and Materials Program, Office of Technology Assessment, Washington, DC 139
  Prepared statement 142
Stephen Wiel, commissioner, Public Service Commission of Nevada, Carson City, NV, and member, Committee on Energy Conservation, National Association of Regulatory Utility Commissioners 161
  Prepared statement 164
Scott Sklar, Director of Government Relations, Solar Energy Industries Association, Washington, DC, accompanied by Carlo Laporta, director of research 171
  Prepared statement 173
Questions and answers for the record:
  Dr. Blair 190
  Mr. Wiel 205
    NARUC convention resolution No. 5 213
    NARUC convention resolution No. 6 214

March 5, 1985—Continued
  Questions and answers for the record—Continued — Page
    Mr. Wiel—Continued
      NARUC convention resolution No. 7 215
      Amory B. Lovins, "Saving Gigabucks with Negawatts," remarks to the Panel "Energy Conservation: A Cornerstone of National Independence," 96th Annual Convention, National Association of Regulatory Utility Commissioners, Los Angeles, CA, November 26, 1984 216
      Jon Wellinghoff and Cynthia Mitchell, "Utility Resource Planning: The State of Nevada Adopts an Integrated Planning Model," ACEEE 1984 Summer Study of Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, August 1984 231
    Mr. Sklar 248
      Jeffry J. Erickson, "Statistical Analysis of the Solar Energy Industry," prepared for Solar Energy Industries Association, 1985 250
  Additional statements for the record:
    Dr. Allen M. Barnett, professor, Electrical Engineering Department, University of Delaware, Newark, DE 267
    Prof. David Pimentel, College of Agriculture and Life Sciences, Cornell University, Ithaca, NY 270
    Glenn H. Lovin, president, International Cogeneration Society, Washington, DC 271
    Byron Washom, Solar Thermal Power Division, Solar Energy Industries Association 275

PANEL 1: BUILDINGS CONSERVATION

March 7, 1985:
  David O. Webb, senior vice president, policy and regulatory affairs, Gas Research Institute, Washington, DC 298
    Prepared statement 301
  Orin F. Zimmerman, technical director, Energy Utilization, Electric Power Research Institute, Palo Alto, CA 313
    Prepared statement 316
  Frank M. Coda, executive director-secretary, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA 319
    Prepared statement 323
  Thomas Vonier, president, Thomas Vonier Associates, Inc., Washington, DC, and member, energy committee, American Institute of Architects 328
    Prepared statement 332
    Discussion 350
  Questions and answers for the record:
    Mr. Webb 356
    Mr. Zimmerman 360
    Mr. Coda 363
    Mr. Vonier 366

PANEL 2: INDUSTRIAL CONSERVATION

  Jean-Louis Poirier, manager, Hagler, Bailly & Co., Washington, DC 369
    Prepared statement 373
  Dr. Edward G. Kelleher, director of energy and process engineering and analytical services, Champion International Corp., West Nyack, NY 393
    Prepared statement 396
  Dr. James H. Leonard, vice president for technology, Bethlehem Steel Corp., Pittsburgh, PA, and chairman, Committee on Technology, American Iron & Steel Institute 402
    Prepared statement 406
      "Federal Laboratory-Steel Industry Initiative Summary and Work Plans," prepared for American Iron & Steel Institute at Argonne National Laboratory, September 1984 411
      T.R. Linde, "Reference Materials in the Steel Industry," ASTM Standardization News, February 1985, pages 32–36 468

March 7, 1985—Continued
Dr. John F. Elliott, professor of metallurgy, Department of Materials Science, and Engineering, Massachusetts Institute of Technology, Cambridge, MA .... Page 473
Prepared statement 477
Discussion 481
Questions and answers for the record:
Mr. Poirier 492
Dr. Kelleher 495
Dr. Leonard 497
Dr. Elliot 505
Additional statement for the record:
Peggy Wheeler, Public Affairs Director, National Center for Appropriate Technology, Washington, DC 511

APPENDIX

ADDITIONAL MATERIALS FOR THE RECORD

"ASHRAE Research: 1984-85 Report," A report from the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc 519
"Energy Policy," approved by the Board of Directors, February 2, 1984, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc 542
"Position Statement on Indoor Air Quality," approved by the Board of Directors, July 1, 1982, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc 544
"Current ASHRAE Publications resulting from Cooperative Research with Federal Agencies (excluding standards)" 553
Department of Energy Fiscal Year 1986 Congressional Budget Request, Energy Supply Research and Development, Volume 2, Solar and Other Renewables 554
Solar Energy 554
Geothermal 624
Department of Energy Fiscal Year 1986 Congressional Budget Request, Energy Conservation, Volume 7 646
Appropriation Language 646
Summary of Estimates by Major Category 647
Program Overview 648
Buildings and Community Systems 652
Industrial 688
Transportation 714
State and Local 744
Multi-sector 758
Policy and Management 785

1986 DEPARTMENT OF ENERGY AUTHORIZATION

TUESDAY, MARCH 5, 1985

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Development and Applications,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:40 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the subcommittee) presiding.

Staff present: Dr. Harlan L. Watson, science consultant.

Mr. Fuqua. The subcommittee will be in order. Today we begin our hearings on the Department of Energy's fiscal year 1986 budget request for conservation and renewable energy research and development.

The 1986 request for conservation and renewable energies continues to provide the stability of funding needed to carry out effective R&D. We have a conservation and renewable energy budget request we can work with, and we appreciate that.

Today, following our questions of Under Secretary Pat Collins, we will receive testimony from Dr. H.M. Hubbard, director of the Solar Energy Research Institute. We will then hear from a panel of outside witnesses on photovoltaic and renewable programs in general, followed by a panel on electric utility technologies for the 1990's. And I might say that I have to leave. We have a matter before the House Administration Committee, and I must leave in about 20 minutes to race over there, so don't take it personal.

Please proceed.

[The prepared opening statement of Ms. Schneider follows:]

Congress of the United States,
House of Representatives,
Washington, DC, March 5, 1985.

Mr. Chairman, I would like to thank the subcommittee staff for bringing together this fine collection of outside witnesses as we review the Department of Energy's proposed $21.4 billion Fiscal Year 1986 budget. I would particularly like to thank Nevada Public Service Commissioner Steve Wiel for taking time to appear on behalf of the National Association of Regulatory Utility Commissioners (NARUC). I am greatly encouraged by NARUC's actions recently taken at their annual convention in adopting "least-cost" utility planning resolutions and establishing the Conservation Committee.

I am delighted with the scientific and technological breakthroughs over the past decade that have turned into extremely cheap, commercially available energy efficiency measures, methods, and technologies—hence the term, "least-cost." Despite this phenomenal progress, the least-cost concept remains relatively obscure, and it might be useful for the record to briefly elaborate on some of its achievements to date and long-term value.

This subcommittee has heard in previous years from Dr. Roger Sant, former federal energy official under Presidents Nixon and Ford, and originator of the "least-cost" concept. As Sant has noted, the silver lining to an otherwise stormy decade of energy turbulence since the 1973 Arab oil embargo has been the leaps and bounds in new energy development and applications, particularly in improving the efficiency of end-use, energy- and electricity-consuming devices in the residential, commercial, industrial, and transportation sectors. As the NARUC keynote speaker Amory Lovins noted, this nation has witnessed design improvements in energy-consuming devices such as a doubling of the efficiency of motors and steel mills, a tripling of the energy efficiency of airliners and lighting systems, a quadrupling of the efficiency of refrigerators, furnaces, air conditioners and other appliances, a quintupling of the efficiency of vehicles, and a dramatic 10-fold increase in the improvement of space conditioning in buildings.

According to DOE analyses this improved efficiency is leaving *$80 billion per year* in the pockets of families and businesses to be invested elsewhere. Even better news is that these savings represent but the tip of the efficiency iceberg. Energy experts point out that if the U.S. operated as efficiently as our West European allies, we would save an *additional $200 billion per year!*

Unfortunately, the market remains marred by imperfections and barriers that presently impede the delivery of available least-cost energy services. Not only are consumers and companies paying more money than they need to but the drop in energy demand over the past decade has resulted in over-construction of powerplants that has saddled ratepayers, shareholders and taxpayers with $15 billion due to cancelled plants, and tens of billions of dollars in rate shock looming on the horizon.

Secondly, as the President's Commission on Industrial Competitiveness stated in strong and unequivocal language in their recent report, "Global Competition: The New Reality," "Our Nation's economic leadership—both at home and abroad-faces strong challenges from international competitors. We have failed to respond adequately. Our ability to compete in world markets has been gradually eroding."

Nowhere is American competitiveness being eroded faster than in the energy development and applications of efficiency measures, methods and technologies. Without question the Japanese dominance in fuel efficient vehicles severely eroded the American share of the auto market over the past decade. The Japanese are about to repeat this performance in other areas as well, most notably refrigerators, which consume one-fourth as much electricity as American models, in new aluminum smelting processes that require no electricity, in air-to-air heat exchangers which improve indoor building air quality while recuperating heat and cooling to save money, in second-generation manufacturing facilities producing photovoltaic cells, etc. Equally important, highly efficient production facilities are enabling the Japanese and other nations to produce goods and services at substantially lower operating costs, providing a further market advantage for them and a worsening trade deficit for us.

In addition, as Admiral Thomas Moorer (retd), former chairman of the Joint Chiefs of Staff, said in his introduction to the 1981 Department of Defense study, "Energy Strategy for National Security," this nation could greatly enhance its national security by increasing its reliance upon cost-effective, efficiency measures—in essence, a form of "strategic energy reserve." A point recently reiterated in the Georgetown Center for Strategic International Studies' report on "America's Network Vulnerabilities."

For these and other compelling reasons, I am greatly encouraged by NARUC's adoption of the least-cost resolutions. As NARUC noted in adopting these resolutions, the success of the least-cost planning approach in the Northwest states of Idaho, Montana, Oregon and Washington, being implemented as a result of the Northwest Electric Power Planning and Conservation Act of 1980, clearly shows that it can reduce both the cost of future electric services and the cost of hedging against electric demand uncertainty.

Today, I would like to focus on that part of NARUC's resolutions that calls upon the federal government to support this least-cost process. I would like to note that our subcommittee has been one of the strongest supporters in this area, most notably in providing the funding commitment to national laboratories such as Lawrence Berkeley to research and develop efficiency technologies and least-cost analytical planning tools.

I am most interested in hearing from our NARUC witness ways in which NARUC sees how the federal energy budget, and particularly that part that comes under the purview of our subcommittee, could be of assistance in their tasks as state utility commissioners implementing least-cost planning procedures and policies.

As we move through our review of the DOE budget I would like to request my colleagues to keep one thought in mind: are we allocating precious tax dollars in the wisest ways possible? As noted in the Center for Renewable Resource's report, "Solar at the Crossroads," conservation and renewables has provided the most dramatic growth in new U.S. energy supplies in recent years. They now respectively provide 23% and 9.4% of U.S. energy supplies, compared to 4.3% for nuclear, 21.6% for coal, 23.8% for gas, and 40.8% for oil. Needless to say, dwindling oil supplies are most in need of least-cost replacement, most notably by efficiency measures.

Unfortunately, a $21.4 billion budget request by DOE that only includes a few percent for efficiency measures (and renewables) is misguided. For most of the past decade conservation funding has been sadly lacking or grossly underfunded, although it has proven itself admirably to date and holds out even greater promise for decades to come. Yet, we see DOE submitting a budget that shows a $431 million reduction for conservation since I came to Congress in 1981 (down to $371 million), a nearly $600 million reduction for renewable resources (down to $176 million), a $891 million reduction in the fossil budget (to $243 million), while nuclear has increased more than $200 million (up to $1.2 billion).

I think it may be long overdue for Congress to request DOE to prepare a least-cost analysis that provides justification for each proposed budget. If I read Public Law 95–91 correctly, that was the Congress's original intent in passing the Department of Energy Organization Act of 1977. That law calls upon DOE to advise the Congress on "technologies to accomplish such tasks" that "forestall energy shortages, to reduce waste, to foster recycling, to encourage conservation practices, and to otherwise protect environmental quality." I seriously question whether the DOE budget as it presently stands meets these mandated criteria.

That concludes my remarks, Mr. Chairman, and I look forward to hearing from our witnesses. I would like to request inclusion in the record the NARUC least-cost resolutions and Mr. Lovin's keynote speech at the NARUC annual convention. Thank you.

NARUC Convention Resolution No. 4

RESOLUTION ESTABLISHING THE COMMITTEE ON ENERGY CONSERVATION

Whereas, Cost effective Energy Conservation, as a recognized national goal, will continue to contribute to the efficient consumption of non-renewable energy resources, and assist in assuring that the United States will be in a position to react more effectively to disruptions or sudden supply curtailments or energy resources; and

Whereas, National imperatives indicate there is a need for rededication to energy conservation and for renewed vigor in pursuing national conservation policy; and

Whereas, State regulatory utility commissions should have an active role in the continuing development of national conservation policy initiatives; and

Whereas, The establishment of a standing committee of the National Association of Regulatory Utility Commissioners would support State commissions in their efforts to develop energy conservation initiatives as they relate to the operation and supervision of public utilities and carriers; now, therefore, be it

Resolved, That the National Association of Regulatory Utility Commissioners, assembled in its Ninety-sixth Annual Convention in Los Angeles, California, hereby amends Section 1 of Article X of the Constitution of the Association [95th NARUC Annual Convention Proceedings, page 1944 (1983)] by adding "Committee on Energy Conservation" in alphabetical order.

Sponsored by the Ad Hoc Committee on Energy Conservation.

NOTE: NARUC Convention Resolutions No. 5, No. 6 and No. 7 and Amory B. Lovins' keynote speech immediately follow Stephen Wiel's questions and answers for the record.

STATEMENT OF WILLIAM PATRICK COLLINS, UNDER SECRETARY, U.S. DEPARTMENT OF ENERGY, WASHINGTON, DC, ACCOMPANIED BY DONNA FITZPATRICK, PRINCIPAL DEPUTY ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY; ALAN STREB, DEPUTY ASSISTANT SECRETARY FOR CONSERVATION; DR. ROBERT SAN MARTIN, DEPUTY ASSISTANT SECRETARY FOR RENEWABLE ENERGY; AND FRANK STEWART, DIRECTOR, OFFICE OF STATE AND LOCAL ASSISTANCE PROGRAMS

Mr. Collins. Thank you very much for your comments, Mr. Chairman, and we are pleased that we think that we are more consistent with this committee and we've appreciated the highly professional advice that we have gotten and cooperation with the members of the committee and the staff. I have a statement which I would like to submit for the record, if I may. I will then summarize it.

Mr. Fuqua. Yes, we'll make that part of the record and then if you wish to summarize that's agreeable.

Mr. Collins. Thank you. I'm accompanied today by Miss Donna Fitzpatrick, the Principal Deputy Assistant Secretary for Conservation and Renewable Energy; Mr. Al Streb, the Deputy Assistant Secretary for Conservation; Dr. Bob San Martin, Deputy Assistant Secretary for Renewable Energy; and Frank Stewart, our Director of the State and Local Assistance Programs.

I appreciate this opportunity to appear before you today to provide information on the fiscal year 1986 budget request for the Department's conservation and renewable energy programs. The budget for these programs is very consistent and supports the goals and objectives of the fourth national energy policy plan. The overall goal of the national energy policy is to foster an adequate supply of energy at reasonable costs, as we have said, and the strategies are to minimize the Federal control and involvement in the energy markets, while maintaining public health, safety and environmental quality and to promote a balanced and mixed energy resource system.

I think the fiscal year 1986 budget implements these strategies by supporting development of a mix of technologies that can contribute to energy supply and end use energy efficiency.

In allocating our resources in this budget we're concentrating on applying Federal funds only where they're most effective: in supporting research and development efforts where the potential payoff is high, but which private industry cannot be expected to pursue because the results are difficult to predict or a return on investment would require an exceptionally long time to be realized. Efforts will continue to be focused on improved dissemination of the results of our R&D programs and on expanded collaboration with the private sector.

I would like to briefly summarize for you now our budget request for each of the major program areas. I will speak first about the energy conservation programs. Energy conservation, which we view as the elimination of waste and careful, efficient use of resources, is a very basic component of our strategy. Our research and development and technology transfer programs, of which we're very proud, in conjunction with the private sector efforts, will enable individuals and businesses to take cost effective actions to reduce energy consumption, thereby reducing the need for new supplies. Conservation is, therefore, an important energy resource, which we must manage like any other energy resource. To illustrate, I think despite strong economic growth in 1984, it is estimated that the total energy consumption in that year did not exceed that of 1973, and was far below what pre-1973 trends would have produced had those trends continued. Yet, economic output over the same period of time continued to expand.

To illustrate the gains in the economic energy efficiency we achieved over that period, the amount of energy required to produce a constant dollar of gross national product has declined by more than 20 percent since 1973. Much of this conservation has been achieved in response to higher energy prices and market forces. Hence, reliance on the market is the mainstay of energy conservation policy, with the Department of Energy concentrating Federal funds on carefully targeted technological research and development, with a special emphasis on technology transfer and communication with industry.

The fiscal year budget request for energy conservation programs, under this subcommittee's jurisdiction, totals $99.5 million, which is roughly $10 million more than last year's request. The Department's energy conservation research and development programs are designed to assist in the development of more efficient technologies and also alternative fuels to those based exclusively on fossil sources. In order to carry out these efforts we are requesting funding of $37.3 million for the Building and Community Systems Programs under this subcommittee's jurisdiction. We are also requesting $35.5 million for Industrial Program activities and $26.7 million for Multisector Program efforts, which fall under the purview of this subcommittee.

Let me give you just a few examples of the types of activities that will be undertaken in fiscal year 1986 in our energy conservation programs.

In our Building and Community Systems Program, research will be conducted not only into how to make building shells more energy efficient, but also, how to maintain acceptable indoor air quality levels in "tight" homes. The budget request also reflects increased funding for contracts to develop technologies for direct casting of steel strip. The amounts requested are required for continuation of contracts with United States Steel, Bethlehem and Westinghouse-Armco. Work on both steel casting and advanced sensors has the potential to significantly increase steel industry productivity. This work, like most of our research efforts in industrial conservation, is conducted on a cost-shared basis with our industrial partners.

Our Energy Conservation Utilization Technology Program will conduct research and development of materials with ordered atomic structures, such as nickel aluminide, which have great potential for improving the efficiency and performance of high temperature processes.

Also, $5 million is being requested to support the analysis of approximately 2,000 proposed inventions and development of approximately 40 of those energy related private sector inventions.

Under our State and Local Assistance Programs, $7.8 million is being requested for the Energy Extension Service to enable States to provide tailored information and specialized and technology assistance to small-scale energy users, such as small businesses, local governments, and homeowners, and to help them decide what are their most effective energy conservation, and renewable energy options. This is the first time in this administration that we have proposed a line item here. And that's the same with the State Energy Conservation Programs, as well.

Turning now to renewable energy, and we think that by the way, that that is a—certainly indicative of our commitment to the partnership program we have talked about with States and localities and we hope with trade unions, associations, churches, and others in community in having the most outstanding year in energy efficiency in the history of the country and a 5-year program that I would like to address a little later.

The fiscal year 1986 budget request for renewable energy programs supports the goal of fostering an adequate supply of energy at reasonable costs, by helping to promote a balanced and mixed energy resource system. The fiscal year 1986 budget request for renewable energy programs, under the subcommittee's jurisdiction, is $173 million. Much progress has been made in renewable energy during the last 10 years in terms of technology and institutional advances. Over 6,000 companies are now engaged in R&D, manufacturing, installation, sales and financing of renewable energy systems. Industry is moving to the forefront in renewable energy development, but requires Federal sponsorship in critical research areas to support and sustain technical and financial commitments. We understand we have very many small businesses in the renewable field. In order to conduct the activities which are necessary to sustain the technical momentum established by the Federal research community and industry, we're requesting funding of $9.5 million for Solar Building Energy Systems, $44.8 million for the Photovoltaics Program and $28.4 million for the Solar Thermal Energy Systems. The funding request for Biofuels Energy Systems is $28.4 million. The request for Wind, Ocean Energy Systems Programs are $20.8 million and $3.5 million, respectively. In order to support these solar energy programs, fiscal year 1986 funding is also proposed for technology transfer, capital improvements at the Solar Energy Research Institute, cross-cutting analyses and the generic research assessment effort; $25.2 million is requested for the Geothermal Energy Program, as well as $72,000 for the Geothermal Resource Development Fund.

Although time will not allow me to go into all the details of our programmatic efforts, I'd like to mention just a few of the highlights of the activities in the renewable energy areas, which will be undertaken in fiscal year 1986. In the photovoltaics area, in which the industry has grown to more than 75 manufacturing and supply firms, DOE research and development emphasizes thin-film concepts, because they require less basic materials and are more amenable to automated production. Investigation of the use of molten nitrate salts, which represent the next generation of central receiver heat transfer technology, will be conducted in fiscal year 1986 by our Solar Thermal Program on a cost-shared basis with industry.

In the biofuels area, the Department will continue its support of a medium-Btu scale-up gasification project to define technical and operational boundaries of this promising technological option.

Other research efforts will include studying the effects which wind turbine operations have on the utility network and identification of equipment and reservoirs suitable for the extraction of energy from molten rock.

These are just a few of the examples of activities we'll be carrying out in fiscal year 1986 in the renewable energy program area. Let me conclude, Mr. Chairman, by emphasizing that the budget submitted for fiscal year 1986 represents a balanced and objective approach to sustaining the momentum achieved in conservation and renewable energy research and development. This approach, which is consistent with the goals and objectives of the fourth energy policy plan, includes public and private cooperation, effective technology transfer efforts to enhance the Nation's ability to use the results of our R&D efforts. We are confident that our proposals will increase understanding of the potential for virtually all the most promising energy conservation technologies and renewable energy options and will substantially contribute to the base of technical information required for informed decision making.

Mr. Chairman, we are pleased to have the advice that we have received from the members of this subcommittee, staff, and the Congress and we think that we're coming closer and closer to an agreement on this path that we should be pursuing in both renewable and conservation and State and local assistance programs. We have some very innovative approaches, including our energy efficiency partnership program, which we are launching this year, in an effort to actually cut by 80 percent, the amount of time that we will be able to weatherize the homes of low income Americans. This, along with a very solid research program, which we modified about a year and a half ago, with the assistance of this subcommittee, I think leaves us all in a better position to talk about the thrust and—the overall thrust of where we're going and also to, I hope, join as partners with many State and local governments and associations, churches, labor unions and others in having the most outstanding year in energy efficiency in the history of America. Thank you, Mr. Chairman.

[The prepared statement of Mr. Collins follows:]

STATEMENT OF

WILLIAM PATRICK COLLINS

UNDER SECRETARY

U.S. DEPARTMENT OF ENERGY

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY

ENERGY DEVELOPMENT AND APPLICATIONS SUBCOMMITTEE

U.S. HOUSE OF REPRESENTATIVES

MARCH 5, 1985

Mr. Chairman and Members of the Subcommittee:

I appreciate this opportunity to appear before you today and provide information on the FY 1986 budget request concerning the Department's energy conservation and renewable energy programs. The budget for these programs is consistent with and supports the goals and objectives of the Fourth National Energy Policy Plan (NEPP-IV). I will summarize those parts of the Plan which are relevant to the subject of today's hearing, and discuss related highlights of the FY 1986 budget request.

National Energy Policies and Strategies

The overall goal of our national energy policy is to foster an adequate supply of energy at reasonable costs. This policy recognizes that "adequate supply" requires flexibility in the energy system, with no undue reliance on any single source of supply. The goal of "reasonable costs" suggests economic efficiency within the energy system, so that energy consumers, individual, commercial, and industrial users alike, are not penalized by economic rigidities introduced into the system by ill- advised governmental regulation. The strategies for achieving this energy policy goal are:

- to minimize Federal control and involvement in energy markets while maintaining public health and safety and environmental quality; and
- to promote a balanced and mixed energy resource system.

The FY 1986 budget request for energy conservation and renewable energy research and development programs implements these strategies by supporting development of a mix of technologies that can contribute to both energy supply and improved end-use efficiency. In allocating our resources, we are concentrating on applying Federal funds only where they are most effective; in sponsoring research and development (R&D) where the potential payoff is high, but which private industry cannot be expected to pursue because the results are difficult to predict or a return on investment would require an exceptionally long time to be realized.

In order to carry out this strategy we have proposed a budget for Conservation and Renewable R&D programs under this subcommittee's jurisdiction which total $273 million; $100 million for Energy Conservation programs and $173 million for Renewable Energy programs. The proposed budget reflects the commitment to support a mix of technologies, which is one of the strategies to achieve our energy policy goal.

I would like now to discuss each of our major program areas under the Office of Conservation and Renewable Energy and its related FY 1986 funding request.

FY 86 BUDGET REQUEST FOR ENERGY CONSERVATION

The FY 1985 budget request for energy conservation research and development programs under this subcommittee's jurisdiction totals $99.5 million. The FY 1986 request is roughly equal to the FY 1985 Congressional appropriation. It includes $37.3 million for Buildings and Community Systems, $35.5 million for Industrial Programs, and $26.7 million for Multi-Sector programs.

Buildings and Community Systems

The buildings sector accounts for approximately 36 percent of our total national energy consumption. In residential buildings, space heating, lighting, and air conditioning use the largest amounts. Significant energy savings can be achieved by improving the efficiency of these and related building functions. The goal of our Buildings and Community Systems research is to advance the technologies that will make these savings possible.

The FY 1986 budget for the Buildings and Community Systems is $37.3 million. These funds will be used to conduct two major efforts: (a) research and development into advanced technologies that will increase the energy efficiency of buildings; and (b) information and technology transfer activities that will make the results of our R&D available to potential users.

We are requesting $12.9 million for the Building Systems subprogram in FY 1986 to continue support for a variety of research and development, including: methods of making building shells more energy efficient; ways to maintain acceptable air quality in energy efficient buildings; methods to predict and measure the energy performance of buildings to make them more energy efficient. We are also proposing new initiatives to investigate the impact of design techniques and construction quality on the energy efficiency of buildings and to begin development of a quantified definition of lighting quality needed for commercial building guidelines and consensus standards.

The Technology and Consumer Products subprogram conducts research that will increase the efficiency of energy-related equipment used in buildings. We are requesting $9.4 million for this subprogram. These funds will be used for research into advanced technologies which support development of thermally activated heat pumps, advanced lighting concepts, combustion heating systems, and refrigeration equipment and appliances.

The Community Systems subprogram supports research leading to the development of community-wide energy delivery and energy management systems. We are requesting $2.0 million for this subprogram. It will be used for research to advance district heating and cooling systems technologies, for assistance to cities in assessing the feasibility of district heating and cooling for their communities, and for studying the impact of site design and orientation on energy use in clusters of buildings.

Our information and technology transfer activities for the Buildings and Community Systems program are carried out under the Analysis and Technology Transfer subprogram. Recognizing the importance of making the results of our research available to the private sector, I want to emphasize the importance we attach to this program in FY 1986. We are requesting $3.4 million for it, which will enable us to expand our technology transfer activities. This expansion includes new initiatives to facilitate voluntary energy conservation programs by the utilities, research on consumer responses to help us improve the effectiveness of our information and technology programs, and a fellowship program to help support buildings energy studies by university and industry researchers at the national laboratories. We also propose to continue our cooperative efforts with the International Energy Agency and our program assessment and research utilization activities. These funds will also enable us to carry out a study that the Rural Housing Amendments Act of 1983 requires us to conduct to compare the energy impact of national manufactured housing safety standards with HUD and Farmers Home Administration standards.

We are requesting $2.2 million for capital equipment in support of the Buildings and Community Systems program in FY 1986. These funds will be used to continue to equip the Roof Test Center at the Oak Ridge National Laboratory, and for diagnostic, computer data logging, and laboratory test equipment to support indoor air quality, building equipment, district heating and cooling and FEMP program activities at DOE national laboratories and universities.

Finally, we are requesting $3.5 million for program direction funds to cover personnel salaries, benefits, travel, and other support to manage all the Buildings and Community Systems programs.

Industry

The FY 1986 budget request for the Industrial Programs is $35.5 million. These funds will be used to carry out work in four subprograms: Waste Energy Reduction, Industrial Process Efficiency, Industrial Cogeneration, and Implementation and Deployment. The goal of these activities is to encourage improved energy efficiency in industry, which accounts for approximately 37 percent of total U.S. energy consumption. The Department's activities in the industrial area consist of a comprehensive program of carefully targeted technological research and development, combined with technology transfer and other implementation efforts. The R&D activities focus on selected high risk ventures which are not likely to be pursued by the private sector alone and most are carried out by private institutions operating under cost-shared contracts or cooperative agreements with the Department.

The Waste Energy Reduction subprogram supports research and development on improved combustion efficiency through oxygen enrichment, improved burner designs, and sophisticated combustion controls; waste heat recovery by development of industrial heat pumps, high temperature recuperators, and ceramic materials for heat exchangers; and research into waste materials utilization and CO_2 generation and recovery. In FY 1986 $12.3 million is requested for this subprogram.

The Industrial Process Efficiency subprogram includes R&D for a major effort in thin strip casting of steel, inert anode materials, advanced sensors and control systems, advanced separation systems, and gasification of wood-derived process liquids for use as fuel. In FY 1986 $13.5 million is requested for this subprogram. This R&D effort is aimed at achieving as much as 1.0 quadrillion BTU worth $5 billion of potential energy savings per year.

The Industrial Cogeneration subprogram focuses on research for externally-fired Brayton cogeneration systems, cogeneration systems powered by diesel engines fired by water slurries, and thermionic burner systems. In FY 1986 $4.7 million is requested in this area.

In addition to the R&D projects which will be funded by the FY 1986 request, there are a number of other R&D projects which are ongoing and supported by prior year funding. These projects include fluidized-bed waste heat recovery systems, conversion of waste materials, laser based sensors, sensors for papermaking processes, separation systems, and cogeneration component research, all of which have significant energy conservation potential.

The Implementation and Development subprogram continues support for the Energy Analysis and Diagnostic Centers at 12 universities, carries out the Congressionally mandated Industrial Energy Efficiency Reporting program and supports a number of activities for technology transfer. These include targeted workshops, support to selected energy conferences, and the development of written materials describing the industrial energy conservation technology and R&D results. Altogether, $3.2 million is requested for this subprogram.

Multi-Sector

The Multi-Sector Program includes the Energy Conversion and Utilization Technologies (ECUT) program, the Energy Related Inventions program, and the National Appropriate Technology Assistance Service (NATAS). The FY 1986 budget request for Multi-Sector includes $20.7 million for ECUT, $5.0 million for the Energy Related Inventions program, and $1.0 million for NATAS.

The Energy Conversion and Utilization Technologies research programs are oriented toward basic research and crosscutting R&D problems common to more than one energy consuming sector. They also provide predictive models and design tools useful to the private sector in achieving greater energy productivity. The requested funding will be used to conduct research in four subprogram areas: Combustion and Thermal Sciences, Materials Sciences, Biocatalysis, Tribology, and International Research Monitoring.

In FY 1986 $6.5 million is requested for Combustion and Thermal Sciences Subprogram. Combustion research provides analytical and measuring techniques needed to understand the thermochemical and related processes that take place in the combustion of fuels and in the conversion of the released thermal energy to work. The results of this research are used to develop efficient, clean, and reliable combustion systems and devices. Thermal Sciences research develops improved thermodynamic analytical capabilities and experimentally validated computerized data bases. These are needed to provide the technological base used to improve heat transfer processes, reduce heat transfer surface area requirements, and minimize vibration induced by fluid flow through heat exchangers. In FY 1986 research will continue to develop advanced analysis techniques and to generate a technological data base for the physical sciences of thermodynamics and heat and mass transfer.

The $6.0 million requested for Materials research will be used to investigate and modify the characteristies of high-temperature materials, lightweight materials, and corrosion resistant materials. Certain materials such as Long-Range Ordered (LRO) Alloys and Intermetallic Compounds, both of which have highly ordered atomic structures, have great potential for improving the efficiency and performance of high temperature processes, but have not yet been utilized because of their characteristic brittleness. Also, research on high-temperature materials in other areas will be expanded in FY 1986. The $3.3 million requested for Biocatalysis research will be used to establish a technological data base for the development of new techniques to manufacture industrial and commercial chemicals using biological systems analogous to conventional processes in chemical engineering. The 3.3 million requested for the Tribology subprogram will be used for research on lubricants, friction and wear to ceramics, and coatings on machine tools that reduce heat and last longer.

Other ECUT funding requested in the proposed FY 1986 budget will be used to assess the status of foreign technologies related to energy conservation and compare with U.S. technologies.

The FY 1986 budget requests $5.0 million for the Energy Related Inventions program. This program was established to evaluate the technical merits of energy related inventions submitted to DOE and to provide technical assistance and grants to further develop promising inventions. The National Bureau of Standards (NBS) conducts evaluations through its Office of Energy Related Inventions. Promising inventions identified by NBS are directed to DOE for further assistance to investigate sources of private sector funding or for direct support where private sector support is not available. From program inception in 1974 through 1984 approximately 20,600 energy saving inventions had been evaluated by NBS. Based on NBS recommendations, 192 inventions were awarded grants totalling $14 million. Of these, 36 have entered the marketplace generating sales of $110 million and creating more than 900 direct jobs.

In FY 1986, the $5 million requested will support the analysis of approximately 2000 proposed inventions, and financial support for approximately 40 of the most promising inventions. During FY 1986, DOE will continue to work one-on-one with inventors to provide business planning assistance, and will conduct workshops which we have tested and found to be very helpful to inventors in dealing with the various and complicated aspects of commercialization.

Appropriate Technology

The Appropriate Technology program was established to support the development and demonstration of small-scale energy technologies that were matched in scale and nature to local needs. Over 2,000 projects were supported, and almost 900 development projects were completed, to advance the state-of-the-art in appropriate technology. In FY 1983, Congress appropriated funds to establish the National Appropriate Technology Assistance Service, to disseminate information on the energy conservation technologies developed through this program and to give expert advice and guidance in using them effectively. NATAS was established in FY 1984, and to date has received over 4,000 requests for information and assistance.

The FY 1986 Budget Request contains $1 million for NATAS, for the continuation of information and technical assistance to individuals and small businesses.

FY 86 BUDGET REQUEST FOR STATE AND LOCAL ASSISTANCE PROGRAMS

Besides conservation research and development, the FY 1986 budget request supports the conservation grant programs for low-income weatherization, energy efficiency improvements for schools and hospitals, and energy planning and information assistance for State and local governments.

These programs have supported energy conservation activities on the part of States, local governments, small businesses, and individuals since 1976. This support has included direct grants, technical assistance, training for State and local personnel, demonstration programs to encourage technology transfer, and personalized information services. The programs administered by this Office are the Weatherization Assistance Program, the Institutional Conservation Program, the State Energy Conservation Program, and the Energy Extension Service.

These programs have accomplished a great deal since 1976. Over 1.3 million low-income homes have been weatherized. Over 15,000 grants have been awarded to schools and hospitals, funding energy conservation projects in some 38,000 institutional buildings. Comprehensive energy conservation programs and information outreach programs are in place in the 57 States and Territories, and through these millions of people have been aided in using energy more efficiently. Just as important, many efforts initially seeded by these programs have spun off into private enterprises, multiplying the benefits developed and demonstrated.

Much more remains to be done, and in FY 1986 the Department will be steadily increasing its work with States, local governments, and private interests to broaden the base of support and management of these programs -- to move from programs dominated by Federal financial support to a more balanced mix of Federal, State, local government, and private sector support. The FY 1986 Budget Request for the State and Local Assistance Programs represents the first year of a graduated five-year phase down of Federal financial support for the four categorical grant programs -- the Weatherization Assistance Program, the Schools and Hospitals Grant Program, the State Energy Conservation Program and the Energy Extension Service. We intend to request a 20% reduction in funds from FY 1985 levels each year, concluding in FY 1990. Our assumption is that, by accelerating our efforts to encourage our non-federal partners in assuming financial responsibility or in developing self-sustaining programs, the federal funding can be reduced accordingly.

During these five years, DOE will continue to work intensively with States, local governments, and private interests to identify alternative sources of funding for program activities and to transfer to the States and others the knowledge gained from nine years' experience in operating these programs. Many activities have been shown to be sufficiently beneficial that clients will pay for services or financial interests will invest in them. However, we do need to do more in sharing information about these success stories.

Let me briefly describe the status of the Energy Extension Service activities planned for FY 1986.

Energy Extension Service

The Energy Extension Service enables the States to provide tailored information and specialized and technical assistance to small scale energy users -- such as small businesses, local governments, and homeowners -- to help them decide what are their most effective energy conservation and renewable options. EES funds also require a 20 percent State match of funds or services.

EES functions in an integrating and coordinating role for existing resources and delivery mechanisms, and provides demonstrations and evaluations of existing technologies. It connects energy users with the most effective and appropriate energy conservation measures to meet their needs and as a direct result increases the market for energy services offered by the private sector. It also represents a channel for technology transfer common to all States.

The FY 1986 Budget Request of $7.8 million will enable EES to continue to identify, analyze, and evaluate energy conservation technologies and to transfer this information to energy consumers. DOE's program activities will have a two-fold emphasis in FY 1986. DOE will work with State and local governments to craft a new form of the program, spelling out the roles each entity plays and the relationships between them, and increasing the use of State resources to meet State needs. DOE will also work with States and private interests to develop alternate support for effective programs and to encourage private operation of profitable energy services. There are already such spinoff examples -- models for States to follow -- and DOE will encourage additional such innovations.

FY 1986 BUDGET REQUEST FOR RENEWABLE ENERGY

Renewable energy technologies are playing an important role in achieving the national objective of a mixed and balanced energy resource base at a reasonable cost. This objective of our energy policy is not targeted to specific numbers. The Departments R&D proposals are geared to assist the private sector to develop technologies capable of providing for an efficient, flexible energy supply system supporting economic growth and permitting free choice in the marketplace among a wide range of energy options. A private sector infrastructure has emerged and is accepting the challenges associated with incorporating renewables into the energy supply network. These new industries include more than 6,000 companies, which are now engaged in research, development, manufacture, installation, operation, sales, financing, or servicing of renewable energy systems. This spectrum of involvement includes universities, utility companies, Fortune 500 companies, services firms, small-business entrepreneurs, major financial institutions, professional associations, state and local governments, and private citizens.

The private sector is meeting the challange of bringing the first of the renewable energy technologies to the marketplace. The Federal role is focussed on selectively conducting R&D activities that will enable industry to assume greater participation at earlier stages of the R&D process. Industry is moving to the forefront of the development effort and now requires assistance in critical research areas to support and sustain their overall technical and financial commitment.

Within the spectrum of technology development, renewable energy options can be viewed covering the range from immature to maturing and mature. A mature option is one where the technology is relatively developed and close to competitive market levels. Industry involvement is significant and Federal requirements are minimal. Small-scale hydropower provides an example of a renewable technology making an energy contribution today and is receiving only limited Federal support for purposes such as effective technology transfer. A maturing technology is one whose basic concepts are proven and which is beginning to find application in market niches, although applied research is necessary to bring it to broad competitive state. Wind energy is a good example of a maturing technology. Extensive wind farm development in the last four years has resulted in a welcome surge of wind turbine sales. Improvements of understanding in the areas of aerodynamics and structural dynamics are needed for industry to develop technology capable of competing broadly in an unsubsidized market.

Immature technologies are those for which the central concept has been nearly or completely proven, but for which both basic and applied R&D remains. An example of an immature technology is thin film photovoltaic material research. A concentrated effort is underway to identify materials that will provide substantial gains in cell efficiency and reproducibility.

The request for FY 1986 of $173.3 million includes activities that span the development continuum of renewable energy. The request will expand the technological and scientific boundaries leading to improved opportunities and innovative ideas to accelerate the harnessing of the renewable energy resources.

I would now like to address the funding requests for selected major programs.

Solar Buildings

Solar buildings technology addresses the R&D issues associated with both active and passive solar heating, cooling, lighting, and domestic hot water. The FY 1986 budget request for Solar Buildings is $9 million for operating expenses and $.5 million for capital equipment. The advances recorded in the solar buildings area have been remarkable. Aided by technology advances in residential and non-residential research, the solar building industry has achieved estimated annual sales in excess of $1 billion. In active solar, growth has been dominated by the water heating industry. For passive, solar heating has become a marketable and accepted feature of modern residential and commercial building design.

Despite these advances, the industry is dominated by small to mid-sized firms that place major emphasis on developing incremental improvements to product lines and on marketing. A complementary Federal role exists to support targeted long-term R&D activities in areas such as materials and component research and systems research for both analytical data and experimental test purposes. Thin film collector development applicable to desiccant space heating and cooling applications, solar responsive apertures, and high performance thermal storage are examples of research areas where advances can lead to significant energy contributions to solar building load requirements.

The evacuated collector research will involve investigations of alternate materials and design strategies to improve a design that has already experimentally shown the highest efficiency ever achieved by a non-tracking collector. These efforts are aimed at extending both the projected life and operating temperature range of such designs and achieving much lower component and system costs. Thermal storage research focuses upon new materials and component design which may realize the potential flexibility and efficiency of phase change storage for passive solar heating and cooling. Activities in thermal transport will include testing fluidized bed concepts, which concentrate thermal energy from collection surfaces, and thermal diode control mechanisms to transport heat efficiently within buildings.

Systems research efforts concentrate on a number of model validation and experimental test activities. State-of-the-art technology will be tested and evaluated to obtain reliability and durability information. Research on deep penetration core daylighting will proceed using analytical simulations, scale models, and test cells. Additionally, research will be performed to determine optimal combinations of emerging solar materials, components, and systems in different building types within several geographic regions.

Photovoltaics

The past decade of photovoltaics (PV) research and development has been highlighted by the emergence of a struggling but aggressive commercial industry. From just two manufacturers of modules for terrestrial applications, the number of U.S. firms involved in PV manufacturing and system supply has grown to more than 75.

The progress made in the development of PV technology is the result of successful federal/industrial cooperation. The goal of this partnership is to develop PV technology to the point that it is cost-competitive in the U.S. grid-connected power market. This requires a combination of module and system capital cost reductions and efficiency improvements that will result in an eightfold reduction in the price of photovoltaic-generated power from that seen today.

Incorporating technical advances achieved by the Federal Program, industry is ambitiously working to maintain its world leadership. From 1974 to 1984, U.S. module sales have soared from 15 kilowatts annually to 12,000 kilowatts. U.S. industry can now build megawatt size central power stations. Four experimental facilities are now in progress in California. Another market actively pursued by the industry is remote stand-alone applications. U.S. exports, almost exclusively for this market segment, rose 45 percent from 1983 to 1984.

The FY 1986 budget request for Photovoltaics is $43.6 million for operating expenses and $1.2 million for capital equipment. This FY 1986 program proposes to aggressively undertake critical research efforts toward developing advanced technologies that show great promise. The strategy is to continue working with industry to improve the conversion efficiency, life-expectancy, and reliability and reduce the cost of photovoltaic cells and modules. In particular, there is a strong emphasis on thin-film concepts because they require less basic materials and are more amenable to automated production.

Activities in materials research are being directed toward resolving efficiency-limiting characteristics, materials instabilities, and deposition impediments related to thin-film materials. The transfer of silicon ribbon production technology to industry will be completed.

Collector research will focus on problems related to thin-film modules and concentrator collectors based on thin film, multiple-junction cells. In particular, the development of module fabrication technologies, structures, and less costly contacts and interconnections would be pursued. Efforts to reduce the complexity of flat-plate and concentrator module design will also continue.

Systems research will be completed on crystalline silicon module reliability characterization and will begin characterization of thin-film module reliability. Results of life-limiting failure mechanism experiments will be transferred to industry to assist industry in extending photovoltaic system life from approximately ten years to about 30. The DOE Program will also assist industry in establishing standard device measurement procedures and performance specifications.

Solar Thermal Technology

The Federal Solar Thermal Technology Program was established to advance the engineering and scientific understanding of this renewable energy option and to establish the technology base for further development by private industry in the competitive energy market. Today, many different solar thermal concepts for producing electric power and heat (process steam) are technically feasible. Advances in component cost, performance, and reliability have lead to decreased energy costs for proposed solar electric power plants by a factor of eight.

To continue building on major accomplishments, a balanced cooperation has been established among industry, the university and private sector research community, and the Federal government. In this cooperation, industry places considerable effort in the technologies feasible for market development. The Federal effort is concentrated on long-term advanced research. This partnership has realized substantial benefits. For example, building on DOE funded dish electric research, the world's largest privately funded solar thermal parabolic dish electricity generating facility was recently constructed by industry.

Current successes, however, can not ignore the fact that solar thermal costs must be reduced further to $0.05/kWhe, or an equivalent $9/MBtu, to be competitive with the mix of other energy generating technologies. In addition to the capital cost issue, there are other factors inhibiting use of solar thermal technologies. These include efficiency uncertainty, unsubstantiated operations and maintenance costs, perceived technical and financial risk due to lack of operational experience, and unproven system service life.

The FY 1986 budget request for Solar Thermal Energy Systems is $28.1 million for operating expenses and $.3 million for capital equipment. For FY 1986, the primary emphasis of research and development is on developing cost effective solar energy collection technologies. This encompasses concentrators, optical materials, and receivers. Concentrator performance has a strong effect on overall system efficiency. Optical materials, mirrors and lenses, are an integral part of any concentrator. Research is being supported to identify low-cost, lightweight, durable optical materials. Receivers components likewise play a critical role in total system efficiency and research will be pursued to enable the operation of advanced central receivers at higher temperatures.

Research emphasis on energy conversion technology includes processes and components to convert the thermal energy provided by the receiver into electrical, mechanical, or other usable energy forms. The adaptation of heat engines for the parabolic dish electric generation application and the development of lower-cost, high-efficiency energy transport and storage mechanisms will be stressed.

System level research provides real-time data related to operation and maintenance issues. Research will include component integration, system optimization, and the automation of system control. Molten nitrate salts, which represent the next generation of central receiver heat transfer technology, will be tested; and a solar-fossil hybrid power facility shall be conceptually designed.

Biofuels

Biofuels energy systems utilize a variety of organic materials which are converted by thermochemical and biochemical means into gaseous, liquid, and solid fuels. Biofuels technologies are currently playing a significant role in U.S. energy production by supplying approximately 2.5 quads to the U.S. energy budget. Although progress has been made in several developed technology areas, tremendous potential can be identified for other emerging biofuels options.

The FY 1986 budget request for Biofuels is $27.8 million for operating expenses and $.6 million for capital equipment. During FY 1986, the Biofuels Program will focus on key research issues to provide a technology base for private sector development of production and conversion technologies.

A strategy of conducting generic research to reduce technical risks and building an R&D partnership with industry has been established and is beginning to pay dividends in technological advances. As a result, a biofuels industry is beginning to make an impact. One such example is the wood burning gas turbine system for electrical generation. This system provides higher efficiencies and lower capital and operating costs than traditional wood burning systems. The private sector is now providing 80 percent of the funding required to scale-up and refine this technology. Private sector interest in other research areas is also growing. The $2.7 million FY 1985 short-rotation intensive culture program is now receiving $400,000 per year in cost sharing and in-kind support from some three dozen private companies.

Feedstock production research in the short-rotation intensive culture area will include genetic hybridization to improve biomass yields and site adaptability, along with tissue culture techniques for breeding and physiological studies. The long-term viability of monoculture plantings, their susceptibility to pests and diseases, and potential yields over coppice successive resproutings shall also be examined. Microalgal species will be screened for high algal oil production and experimental-design algal growth units are to be tested for crop management approaches and design adaptations.

A central activity in thermochemical conversion research will be continuation of the scale-up medium-Btu gasification process. This effort, cost-shared with private industry, will define technical and operational boundaries. In the area of municipal solid waste (MSW), research will include: combustion investigations to improve efficiency and steam quality; identification of reactor designs for proper heating rates and conditions; and examination of the basic reaction mechanisms in the MSW gasification/pyrolysis. Liquids fuels research will include the identification and testing of catalysts that can upgrade MSW pyrolytic liquids.

The biochemical conversion program will use genetic engineering techniques to develop improved organisms with superior capability for hydrolysis and fermentation. An acid recovery system will be incorporated into the TVA test-bed facility for small-scale testing. The RefCOM Refuse to Methane Conversion test-bed facility will examine high solids loading of MSW in anaerobic digestion. The microbial populations responsible for methane production in sanitary landfills will also be investigated.

The regional program will continue its work in the Pacific Northwest, Southeast, Northeast, and Great Lake States regions, with greater cost-sharing by industry and state and local governments. Efforts will focus on defining the availability of resources within each region, working with the private sector to eliminate barriers to biofuels applications, and continuing to disseminate information and technical advice to potential users of biofuels technologies.

Wind Energy

The use of wind energy has dramatically increased in the U.S. during the last five years. In 1981, 5 MW of wind turbines were installed in utility applications. By 1984, this figure rose to 650 MW.

The FY 1986 budget request for Wind Energy is $20 million in operating expenses and $.8 million for capital equipment. The Federal government wind energy program was initiated to establish a scientific base of understanding and to accumulate a data base of operational experience.

In the early 1980s, private sector involvement moved from prototype development under DOE sponsorship to commercial advancement and marketing of second generation designs. A noteworthy example of transferring R&D to private industry is the Darrieus (egg-beater) vertical axis wind turbine. Originally developed as an experimental prototype, this concept has become an accepted commercially available method of wind energy conversion.

Today, wind technology is at a crossroads. Thousands of small and intermediate-sized turbines are operating in wind farms. More than 30 U.S. companies are marketing their own designs along with dozens of foreign manufacturers. However, much of this industry tends to use a "hands-on, fix it when it breaks" approach to product development and improvement. Even so, wind turbines now installed operate more reliably than those of just a few years ago.

What has not progressed at a commensurate speed is the understanding within industry or the nation's research laboratories of the basic sciences that underly the technology. Operating experience and research on DOE experimental machines have shown that the assumptions widely used to design machines are simplistic and inconsistent with field experiment observations. The wind resource has been shown to be significantly more complex than anticipated. Although the average wind seems steady, over the modest size area defined by a rotating blade and during the span of only a few seconds, it is turbulent, varying in three dimensions, and constantly changing. In a series of DOE-sponsored meetings to solicit industry insights into research requirements, a repeated recommendation was that DOE pursue a program of generic research targeted to resolve these technical issues.

For wind energy to be a viable long-term energy option that can produce large quantities of electricity in the marketplace, industry must achieve reductions by a factor of 2 to 4 times in the cost of wind-generated electricity. A reduction of this magnitude is achievable only through a carefully targeted research program that addresses major technical challenges. The research program outlined for FY 1986 focuses on meeting these challenges.

Aerodynamics research activities will examine the fundamental processes resulting from wind forces acting on the turbine rotor. Major areas of emphasis include aeroelastic responses, blade loading, dynamic stall, and airfoil performance. Additionally, a program of cooperative research to use windfarms and other existing machines shall be undertaken to gather fundamental data on aerodynamic phenomona and to validate structural and aerodynamic models.

The structural research program will focus on basic sciences that address materials stresses, component lifetime, and turbine dynamic interactions with the power grid that result from structural responses to the wind. The effect which wind turbine operations have on the utility network is also an area that requires further DOE attention if wind technology is to achieve technical maturity.

The Wind Energy Research Center at the Solar Energy Research Institute continues to provide industry with analytical and experimental facilities to test prototype designs.

For FY 1986 final DOE funding is proposed to close the MOD5(B) multimegawatt turbine development project. Completed design and test data will be available for continued advancement of this technology by the commercial sector.

Ocean Energy

The FY 1986 budget request for Ocean Energy is $3.5 million for operating expenses. The oceans are the largest collector and storage system for solar energy in the world. This energy is evidenced in the form of waves, currents, salinity gradients, and thermal gradients. Over the years numerous techniques for extracting this energy have been proposed and assessed. To date, Ocean Thermal Energy Conversion (OTEC) is the most feasible technology option.

The planned evolution of OTEC is one of new technology development, notably achieving quantum reductions in projected costs of closed and open-cycle OTEC. The successful development of open cycle technology rests on the resolution of critical technical problems.

The strategy of the program is to focus on the technical uncertainties of 5-15 MWe size OTEC near-shore systems. The FY 1986 program is predicated on this strategy and will lay the foundation for attaining OTEC system capital costs of $7200/KWe in five years, and $3200/KWe by the late 1990s.

Thermodynamics research activities will examine the fundamental issues associated with removal of noncondensable gases critical to the feasibility of open-cycle OTEC. There will also be research in waterside enhancement of advanced heat exchangers, particularly the condensers applicable to both open-and closed-cycle. Less expensive bonding and fabrication methods for these advanced heat exchangers which take advantage of low OTEC operating temperatures, will be addressed.

Cold water pipe research will be performed within the materials and structures activity area. Primary concentration will be on validation of computer programs for predicting loads, design, and performance.

Finally, in the experimental verification area, activities will focus on upgrading the Hawaiian Seacoast Test Facility. This facility, cost-shared by DOE and the State, will serve as the test bed for the ocean-thermal industry.

Other Solar Activities

To support planned research efforts in individual solar energy technologies, several functional program elements are also being proposed for FY 1986 funding.

Recognizing the importance of transferring DOE R&D results to non-Federal sectors in an orderly and timely manner, FY 1986 funds are requested for $3.1 million in operating expenses for Solar Technology Transfer. Standing publications will be updated and notification of available services will be disseminated to potential users.

The development of renewable energy is a dynamic process, always changing to take advantage of new advancements and meet emerging obstacles. Requested FY 1986 Program Support funds are designated for updating DOE solar and renewable energy multiyear technology R&D strategies, conducting ad hoc analyses, and providing for the continuation of technical and analytical services.

The Solar Research Institute (SERI) in Golden, CO, serves as the National center for solar energy research. To fulfill this responsibility, capital improvements are required for current and future research assignments. Funds totaling $2.3 million for general purpose equipment and eleven building and site improvement projects are being requested.

Information pertaining to the distribution and variability of solar resources is critical for designing new experiments, interpolating field data, and siting solar energy conversion systems. For these reasons, a solar resources assessment initiative is requested for FY 1986, for $950,000 in operating expenses and $50,000 in capital equipment funds. Resource management, modelling, and measuring techniques are areas which will be investigated within this program element.

Geothermal Energy

When the R&D program in geothermal energy was initiated more than a decade ago, the only significant geothermal electric power generating source in the United States was the natural steam system at The Geysers in California. Today, geothermal energy uses are evident by the production of electricity from eight reservoirs, and over 200 direct heat application facilities in several states. It is estimated that more than 7 trillion kilowatt hours of electricity were produced from 1500 MW of United States dry steam geothermal resources in 1984.

The technologies for extracting geothermal resources vary widely depending on the form in which they occur (steam, water, or dissolved gas) and become increasingly challenging from a technical perspective as the depth and temperature of the resource increase. The DOE Geothermal Program addresses these variations, with a balanced concentration between long-term, high-payoff research and R&D activities to assist industry meeting nearer-term technical objectives. The purpose of this strategy is to provide a technical knowledge base for industry to utilize all forms of geothermal energy.

The FY 1986 budget request for Geothermal is $24.7 million in operating expenses and $.5 million in capital equipment funding. Confidence in geothermal development has been exhibited by industry's development of hot water reservoirs for power generation. Geothermal drilling costs are high, up to four times the cost of oil and gas wells, and the utilization technologies are new and surrounded by uncertainties. Despite these factors, industry has proven its willingness to participate in technology development as major feasibility issues are resolved. The FY 1986 geothermal program emphasizes research activities to compliment industry development initiatives. The Program is focused on issues of technical uncertainty, balanced with efforts to transfer technologies that have significant energy potential in the upcoming years.

Hydrothermal research is focused on unresolved issues in utilizing the hot water resource. Experiments are planned to evaluate brine fluid handling, improve reservoir characterization techniques, and investigate binary cycle energy conversion and geothermal system materials. These activities will help expand the economically exploitable hydrothermal resource base.

Geopressured brines present issues significantly different from those of the hydrothermal resource. There is still uncertainty on the costs of drilling and completing wells in high pressure zones and even greater uncertainty on the average size, rate of production, and longevity of individual reservoirs. Research in this area will involve well testing to establish long-term, high-flow rates. The reservoir testing program will also be used for cost-shared electric power generation experiments with industry, the first with geopressured brines anywhere in the world.

The hot dry rock research will continue energy extraction experiments utilizing the very large man-made reservoir created over a year ago. The technology economics and longevity of a large scale reservoir must be determined before development of this geothermal energy resource will be considered by industry. Japan and West Germany have participated in the DOE Hot Dry Rock Program since 1980.

Magma, or molten rock, is the largest estimated geothermal resource and also the most difficult from which to extract heat. While the scientific feasibility of extracting heat from magma has been established, the technology required for extraction is still in the very early research stages. Materials for drilling equipment and heat exchangers must be identified that can withstand temperatures up to 1200°C and corrosive environments. Geophysical measurements of selected sites will also be made to identify resource areas favorable for downhole experiments.

Geothermal Resources Development Fund

The Geothermal Resources Development Fund was established to broaden the geothermal energy technology base by guarantying loans for private sector development of several state-of-the-art facilities. The FY 1986 request is $72,000 which allows for evaluating pending loan applications, restructuring existing guaranty agreements, and monitoring outstanding loans.

CONCLUSION

These energy conservation and renewable energy technologies show enormous potential for the future. Collectively, their potential applications make them highly attractive candidates for private sector development and deployment. These technologies promise increased energy supply diversity and end-use efficiency and should serve to promote increasing competition within the energy marketplace. Their development will also enhance the ability of the private sector to respond rapidly to unpredictable fluctuations in supply and price of fossil fuels.

The program presented for your review today represents a sound and stable commitment to the continuing development of these technologies. We are confident that our proposals will increase understanding of the potential for virtually all of the most promising energy conservation technologies and renewable energy options and will substantially contribute to the base of technical information required for informed decision making by industry and consumers.

Thank you for the opportunity to present our budget request.

DISCUSSION

Mr. **Fuqua**. Thank you very much. You indicated in your prepared remarks, which we have included in the record, that the energy conservation and renewable program presented for the committee's review, represents a sound and stable commitment to continue development of these technologies, which we all agree, but how is that view going to be incorporated into the upcoming DOE fifth national energy policy plan that's to be issued next month?

Mr. **Collins**. We have—Mr. Chairman, I'm glad you brought that up. We've had some outstanding contributions to that from members of——

Mr. **Fuqua**. The last guy that used that statement didn't fare too well in public office.

Mr. **Collins**. Sir?

Mr. **Fuqua**. Go ahead.

Mr. **Collins**. The contributions to the NEPP-5 and it is very consistent with our budget efforts. Quite frankly it's pretty—it's very consistent with what we came out of the Congress with last year, with what I think we presented and we think that probably we're just taking the next step with this budget and I do not think that there will be anything that's in the upcoming national energy policy plan, which will be inconsistent with what we have in this budget.

Mr. **Fuqua**. Last year we asked for some comments about the results regarding—or the impact of the R&D and investment tax incentives. Are you working on that report and is it available? Will it be available to us reasonably soon?

Mr. **Collins**. Well, Mr. Chairman, we've been working at reports on—well, reports or comments or trying to participate in the process on every one of the proposals that have generally surfaced in the Congress on energy tax credits, in general, and how that needs—the path that we need to pursue. As a report, per se, we have data on every one of those proposals, I think, that have surfaced that we're glad—that we're more than pleased to share with this committee. As far as formalizing that in a one-shot effort, if that is helpful, of course we're pleased to do that. If sharing the data on all the proposals that have come up and all the analysis that we have done on them is more helpful, we'll be glad to do that. Whatever fits——

Mr. **Fuqua**. Are you requesting $5 million for the Energy Related Inventions Program? What have we got out of this program to date?

Mr. **Collins**. Well, we're very pleased about that, Mr. Chairman. We raised that by about 67 percent 2 years—a year ago in our request to Congress and we're pleased that you funded it at that level. We have about 2,000, as I said, a year of suggestions by inventors around the country and about 40 of those will be funded. About 325 of those are in the process right now. They will all be analyzed by the National Bureau of Standards and we even brought an example from the State of Florida with us today that has worked very well in a tomato program, for example, and to cite another one that's been extremely successful in the 17-stop tour by the National Gas Vehicles around the country this year. The cylinders that held the natural gas in those vehicles were made by an industrial arts teacher, who has now had 13 different inventions come through that program. We're very pleased about the success of that program. We also have the tomatoes to show if you'd like.

Mr. FUQUA. I hope they're not the baseball type that——

Mr. COLLINS. No, no, these——

Mr. FUQUA [continuing]. That some circles are growing them for.

Mr. COLLINS [continuing]. These aren't political tomatoes, no.

Mr. FUQUA. The item you talk about in the technology and consumer products area, there are some research activities associated with mercury isotope enrichment. Is that intended to be a cost-shared program to design and build and scale up?

Mr. COLLINS. Absolutely, Mr. Chairman. We're very pleased that GTE is the lead company in that and it's a result of, of course, our nuclear research and it's one of the places we can see cooperation that may lead to substantial savings, possibly even a quad of energy and we hope that—we have had several meetings of the top executives involved in the various parts of the Department of Energy in getting this from one section of research and some of it, as you know, has been funded in the classified area, out into the public sector and it's a good example of cooperation in the Department.

Mr. FUQUA. Well, haven't you reduced your technology transfer program?

Mr. COLLINS. Well, Mr. Chairman, we asked actually for more than the Congress gave us last year, but we have reduced our request, because, just as last year, we increased our request about 90 percent in the conservation and renewable energy budgets. As a result of the discussions with this subcommittee and others, we saw what the Congress was telling us last year and in every instance but one we do have a higher request than the Congress did fund last year in technology transfer because we do feel so strongly about it. But, we did take the signal that we got from Congress, and we did reduce it somewhat.

Mr. FUQUA. Mr. Walgren.

Mr. WALGREN. Thank you, Mr. Chairman. I wanted to ask about the steel work that you mentioned in your testimony. You say that you're requesting a $3.4 million increase, is that right, in the slab and thin strip casting program?

Mr. COLLINS. Right.

Mr. WALGREN. Can you outline where you are now in that program? What are you spending this year if you're asking for a $3.4 million increase?

Mr. COLLINS. I would like, if I could, Mr. Walgren, to defer to Mr. Al Streb to outline that in detail, if he would.

Mr. STREB. Mr. Walgren, the—you may be familiar with the background of this program. This began about 2 or 3 years ago. We started by evaluating four different systems for thin strip casting with four separate contractors. Last year, as a result of an initiative by the Congress, a substantial increase in the funding available was appropriated. We solicited proposals from steel companies and selected a team, United States Steel/Bethlehem Steel to pursue, what I would call, the primary activity in that regard and this is a success oriented program, which begins with two approaches, a horizontal casting approach, and a vertical casting approach and will eventually home in on one. A pilot will be built. We anticipate that the total contribution by the Federal Government, in this regard, will be on the order of $28 million. The private sector is sharing substantially, the companies who are participating are contributing both financial resources and effort in kind, in the amount of $4 or $5 million.

Now, as a parallel effort, because we view this as an activity which has such great implications for the steel industry, we're pursuing an alternative approach, which, I guess would be best characterized as a slightly more advanced approach, also higher risk, with Westinghouse and Armco Steel, involving direct casting on a wheel with electro magnetic confinement of the molten material. This is being performed at a very much lower level. I believe that the total contribution by us to that particular program, at this point in time, is on the order of a million dollars.

Mr. WALGREN. What's the total contribution this year to the other part of the program that we're shooting in total for $28 million over, I take it, a number of years; is that right?

Mr. STREB. There is $8 million which is requested for that particular line item and I believe that the bulk of that is going to United States Steel/Bethlehem. Let me——

Mr. COLLINS. Yes, that's correct.

Mr. STREB. That's true. The entire $8 million is going to the United States Steel/Bethlehem activity.

Mr. WALGREN. Would I infer then that this year $4.5 or so million is going into that same program?

Mr. STREB. Less than that. I think it is on the order of $3.5 because a million dollars of the 1985 funds is going into this alternative effort.

Mr. WALGREN. I see. Can you give us any reactions to the progress in the project at this point?

Mr. STREB. Well, I think that——

Mr. WALGREN. Is it very real?

Mr. STREB [continuing]. It is rather early. The contract—the major contract effort with United States Steel/Bethlehem was not negotiated until the September 30 of last year, so they're really just gearing up and beginning their work. Basically laying their plans for the first series of very small pilot runs.

Mr. WALGREN. What has been their contribution this year from the private sector? You say we have $3. something million in and you're looking for $4 million overall from the industry over the whole program, through the pilot plan. What's the private sector's ante thus far?

Mr. STREB. Mr. Walgren, I will have to furnish that for the record, but I suspect that the early stages of the activity, as is the case in most of the programs that we sponsored, is primarily——

[The information follows:]

PRIVATE SECTOR CONTRIBUTION TO THIN STRIP CASTING PROJECT THUS FAR

The total expenditure on this project to date has been $2,082,000 of which $258,168 was from United States Steel and Bethlehem Steel.

Mr. WALGREN. Federal.

Mr. STREB. Federal, that's correct.

Mr. WALGREN. I see. All right. Who can respond to solar energy and the thoughts about this multimegawatt turbine program that is apparently being terminated? Is that right?

Mr. COLLINS. The MOD-5, I think, when the activities——

Mr. WALGREN. Yes, yes, this is a wind program.

Mr. COLLINS. Yes, right, sure.

Mr. WALGREN. The question would be, we're apparently terminating that program.

Mr. COLLINS. Yes, sir.

Mr. WALGREN. How much do we have in it? You have $1.3 million for closeout costs in here. What's been our investment in that as taxpayers and what have we accomplished with the program that we're ending?

Mr. COLLINS. Well, Mr. Walgren, I'd say that the plan that we have for that this year, we have offered industry some opportunities to cost share on this, worked extensively in making these offers. They weren't willing to pursue it further. We will complete the research, in essence, this year, the next fiscal year—this fiscal year rather and I think at that point, unless there were some efforts to cost share extensively, which there doesn't seem to appear to be and we worked over 1 year on that, that we will have done the basic and applied research.

Mr. WALGREN. How much—how long have we been working on that and what has it cost us?

Mr. COLLINS. Yes, I'd like to ask Mr. Bob San Martin, our Deputy Assistant Secretary for Renewables, to go into that further. I think it's about $50 million.

Dr. SAN MARTIN. We have—through 1985 would have committed approximately $48 million to the MOD-5 development program. And I must apologize that I—what we have gotten out of the program is that a substantial amount of new technology has been developed that's generically applicable to many other wind development efforts that are going on in the private sector. We would assure that all of the data that was developed was transferred to be exploited by the industrial base.

Mr. WALGREN. Perhaps I could leave the record open and ask for a submission of some further description of the value that you feel has come out of that program. What was the total cost again? I'm sorry.

Mr. COLLINS. $48 million.

Dr. SAN MARTIN. $48 million is the amount that has been invested to date.

[The information follows:]

MOD-5 ADVANCED MULTIMEGAWATT WIND TURBINE PROGRAM BENEFITS

The Federal Government will have invested upon termination over $60 million in the MOD-5B wind energy turbine program including NASA research and support. These efforts have resulted in much new knowledge being applied throughout the wind energy industry. As presently defined, the MOD-5B wind turbine incorporates many advanced features that represent significant improvements in terms of performance, cost and reliability over current wind turbine systems such as the MOD-2 large scale turbine design. These improvements include: variable speed operation for intermediate and large machines, advancement in control systems, aerodynamic augmentation such as vortex generators, and structural dynamic load modelling.

Also, to the maximum extent possible, certain advancements planned for MOD-5 have been adapted in to existing MOD-2 machines. A complete MOD-5B detailed design, with engineering documentation, will permit further use of resulting tradeoff studies, engineering analysis and advanced design techniques by the entire wind energy industry.

Mr. **Walgren**. The Chair would recognize Mr. Packard.

Mr. **Packard**. May I suggest that the ranking member of our subcommittee go first. He has another appointment and I'll certainly defer to him.

Mr. **Sensenbrenner**. Yes, thank you, Mr. Chairman, and welcome to Mr. Collins and entourage. I have known Mr. Collins for a number of years and this is his first entry into the bureaucracy and I see that you fit in well. You have four of your friends along with you rather than doing it yourself. One of the concerns that I have had as a member of this subcommittee is pork barrel projects and cost overruns and I think we've got one that falls under the jurisdiction of this subcommittee in the authorization of Northwestern University. In the last Interior Appropriations bill, the chairman who represents that area slipped in $16 million for a basic industry research lab at Northwestern University in Evanston, IL. I'm informed that the cost has now jumped to $26 million and that DOE did not request any additional funding for the Northwestern project in the fiscal 1986 budget. A number of questions arise as a result of that. First, what is its status? Second, is Northwestern going to pick up the cost overrun or are we going to be asked to pick that up as a government? Next, does the Department of Energy believe there is a national need for this facility, and do you endorse it? Fourth, will the Northwestern lab fit into the existing conservation program? And fifth, where will the program money to fund research at Northwestern come from? In other words, is the construction of the building by the taxpayers a down payment and a further pipeline in the continued operational funding or not?

Mr. **Collins**. Well, Mr. Sensenbrenner, I think I can cover most of those fairly quickly. We did not ask for funding for this project last year or continued funding in the future. It was originally, in all fairness to those who were involved, a $26 million proposal and that through the congressional process and the conference committee, got down to $16. It is—the present situation is that they have not shown us a satisfactory research plan, so we have not funded—are not in the process of funding any research there.

We have, of course, because of congressional direction, gone ahead, through our Chicago Operations Office, in funding the construction of this unit, although the fact of the matter is they need a Form 44, which is a government form, to do that, and that has not been approved yet either. I assume that the assumption is now that may get started around June.

The subject areas that this laboratory is supposed to cover are those which we hold didn't generate a very high priority: tribology and ceramics and basic sciences, as the unit is described. We had plans on doing that type of work at the Oak Ridge High Temperature Facility, however, and so we are in a state of limbo, both on the construction, because the final plan has not been put in, and the research, because they have not given us a final plan on that as well. So, I think that covers most of your questions.

Mr. **Sensenbrenner**. I guess final elaboration is, do you anticipate the request for DOE funding of the ongoing research once this building is constructed or is that going to be something Northwestern will have to take care of themselves?

Mr. **Collins**. Well, I could see, Mr. Sensenbrenner, that they could play a role in our overall work in, for example, tribology and ceramics, but I—from what they envision there—I certainly don't see us funding all the research that they envision at this point in time.

Mr. **Sensenbrenner**. From what you've described this is another case of send the money first and file the plan later.

Thank you, very much.

I have an opening statement that I would like to ask unanimous consent to be included in the record.

Mr. **Walgren**. Without objection.

Mr. **Sensenbrenner**. Thank you, Mr. Chairman.

[The prepared opening statement of Mr. Sensenbrenner follows:]

OPENING STATEMENT OF HON. F. JAMES SENSENBRENNER, JR., EDA SUBCOMMITTEE HEARINGS ON DOE PROGRAMS IN CONSERVATION AND RENEWABLE ENERGY FOR FISCAL YEAR 1986

Thank you, Mr. Chairman, for this opportunity to extend a welcome to Mr. Collins, Under Secretary of the Department of Energy.

Mr. Collins has joined us this morning to discuss the Department of Energy's fiscal year 1986 budget request programs for the Conservation and Renewable Energy Programs.

The importance of increasing the production and utilization of renewable energy sources and improving the energy efficiency of our buildings, industrial systems, and other processes cannot be overstated. Our long-term energy security is dependent upon a more responsible utilization of our limited natural resources and upon the availability of alternatives to these fossil fuels. DOE can be proud of the progress it has made in developing these renewable energy sources and conservation technologies and improving our knowledge of them.

I am delighted this year's budget request will permit a continued Federal role in advancing those technologies which are not quite ready for commercial applications.

Mr. **Walgren**. Mr. Packard.

Mr. **Packard**. Thank you, Mr. Chairman. The report that you've given us has not addressed the coal gasification system. Does it fall under one of the catagories that you do address?

Mr. **Collins**. No, sir, not in this——

Mr. **Packard**. Is there anything in the budget for coal gasification?

Mr. **Collins**. In other parts of the Department of Energy budget, yes, there is. In the fossil area, Mr. Packard, and I'd be glad to submit for the record for your perusal——

Mr. **Packard**. That does not fall under the purview of this committee?

Mr. **Collins**. No, sir.

Mr. **Packard**. I beg your pardon.

Mr. **Collins**. That's fine.

Mr. **Packard**. I have sensed that is one of the more cost-effective experimental programs we've got and I didn't see anything and I was concerned.

Mr. **Collins**. Absolutely.

Mr. PACKARD. The—I do notice a significant amount of money in the budget for coal—for photovoltaic, primarily in the operation of it. And yet, in my touring of the facilities, in my areas at least, in southern California, it does not seem to be a very cost-effective process, at this time. Do you have—is it intended that we continue, from a Government level, to support the operation of the experimental stations that are now in existence?

Mr. COLLINS. Yes.

Mr. PACKARD. I notice we're also going to enlarge those to some modest degree. Could you respond to what our future is in the photovoltaic area?

Mr. COLLINS. Yes, I'd be glad to, Mr. Packard. As you note the key is now production and getting down the cost and also—so we are working mainly in those two areas. Although we do have a reduction in our budget there that's because a project known as the Sacramento Municipal District was not included—a large ticket project. I think that we think it's a very promising technology and, of course, some of the best work is being done and you've probably seen it in your area of the country. The fact—what we're going to try to do there is to up the efficiency, we're working at 12, 13 percent now, we're looking at 20 percent, ultimately 35 percent and also the production ability and the ability to produce this much less expensively. We've basically cut the cost about 1,000 percent in the last 10 years. We think we'll cut it another 1,000 in the next 6 years, and then it will be very cost-effective with other technologies.

As far as the regional centers, we do want to—I think that your question referenced, we do want to cut those back. We would rather put it in a little bit more cost-effective higher level research. I think if we can reach the efficiency and reliability that I just discussed, that photovoltaics will be a very strong competitor.

Mr. PACKARD. And in the wind area, wind equipment and turbines, you're increasing that. Are you optimistic at all about wind as a—in the experimental stage?

Mr. COLLINS. Well, Mr. Packard, we are—and this ties in a bit to Mr. Walgren's question also. Not in the area of the large machines that Mr. Walgren was referring to, necessarily, at this point in time, but in up to 100 kilowatts and now we're very comfortable with technology and price, and now we're working on the 100 to 200 kilowatt area. And we think that there is some very good possibilities there, and of course, they are regional around the country. When you get into the much larger machines that were referenced in Mr. Walgren's question, that—those just don't seem to be the type of things private industry wants to pursue at this point in time for mechanical and cost reasons. to where local or individual farms or homeowners or small gatherings will be using wind rather than using it on a commercial basis, than on a city basis.

I can see certainly farmers and ranchers in, for example, many of the Western States, some of them going back to it as so many of their relatives have in the past, but I think that as long as up until that maybe 200-kilowatt level, I think that there are people who will be comfortable in pursuing that.

Mr. PACKARD. 200 kilowatt will support how many homes?

Mr. COLLINS. Oh, about 50.

Mr. **Packard**. About 50.

Mr. **Collins**. Yes. And that's a possibility, but needless to say there are some environmental constraints that you're familiar with and have been raised in your State and other States as well.

Mr. **Packard**. One last question that I have and that relates, I think, to a change in the structure of the Department. Recent arrangements for—reorganization plans raising the possibility of eliminating the position of the Assistant Secretary for Conservation and Renewable Energy. What status is this initiative in and what effect will it have on the overall activity of the committee—or of the Department?

Mr. **Collins**. Well, we have a legal opinion from the General Accounting Office and then subsequent statements by Secretary Herrington to indicate that we will reestablish that position.

Mr. **Packard**. I see, thank you. That's all I have, Mr. Chairman.

Mr. **Walgren**. The Chair would recognize Mr. Slaughter.

Mr. **Slaughter**. No questions.

Mr. **Walgren**. And following that the Chair recognizes Ms. Schneider.

Ms. **Schneider**. Well, I'm delighted to hear, on the last question that was put to you, Mr. Collins, that Secretary Herrington does intend to reestablish that position. I would like you to elaborate a little bit further as to what that will mean then insofar as the gist or the goals of the agency will be in pursuing conservation and renewable energy programs.

Mr. **Collins**. Well, Ms. Schneider, I think that Secretary Herrington has experience both as an attorney in the private sector, working with people who've been involved with many of these projects, which I think is extremely helpful, because we certainly are concerned that—this is an infant industry and some people expected too much too soon and I think he has—at the same time and particularly for those entrepreneurs who are getting into it and we think the viability of the renewable industry is one of the real keys of our focus this year. And I think that the Secretary is oriented that way and has been looking into those possibilities and will be very strong in helping entrepreneurs help themselves in being successful from a private business standpoint, which we hope will make us successful from a national standpoint in renewable energy in general.

Ms. **Schneider**. And beyond the national success I would hope that the Secretary would also look at our international potential. As we look at our global economy, the President's Commission on International Competitiveness, which recently was reported out on global competition, identified the U.S. trade deficit at $123 billion. This committee has held a number of different hearings on our potential for conservation and renewable export technologies and it seems to me that this is an area that is just so ripe for expansion. You're shaking your head yes, I have the feeling you have some wonderful goodies you want to share with me insofar as your plans on export trade and conservation renewables.

Mr. **Collins**. We're very excited about it. It's one of our two big thrusts. One, of course the viability of the industry, which we discussed and turning around, losing some of our markets, for example, photovoltaics, as we have in the last several years. And then, No. 2, was our committee on renewable energy and commerce and trade. And we initially had a meeting in the photovoltaic industry about 4 months ago, and we followed that up with one for the entire renewable industry about a month ago. And basically we're showing what tools are available. How we can assist. How we can utilize the opportunities in the Caribbean Basin and other places. For example, where the Interior Department pays so much to transport diesel to certain islands in the Pacific, which could quite easily use photovoltaics and other types of resources on a more permanent basis and actually save the Government money.

And the program that Frank Stewart is starting in the State and Local Assistance Programs, I'm extremely excited about. We've penned some numbers, if we can make the strides that we think are very realizable, we can talk about a $30 billion difference in the balance of payments. A little bit of substitution would have to be involved as well. Extremely excited about those initiatives.

Ms. SCHNEIDER. Is there any plan, in your shop, to do a comprehensive evaluation of the competitive state of the conservation energy and some of the export barriers that we're currently facing. Will your shop be doing that?

Mr. COLLINS. Well, partially. We—our conservation shop did an analysis last year, which of course we fed into the Commerce Department, which has the official responsibility on that.

Ms. SCHNEIDER. Right.

Mr. COLLINS. Also we've been working very closely with the Commerce Department through our renewable operation and quite frankly, we've coordinated those two because we have some very small entrepreneurs, generally in the renewables area, that we're concerned about and then we have some larger operators in the conservation area that are worldwide already, but—so we are focusing in on both and we've worked extremely closely with Commerce and I understand that's a first, to some degree, in that type of operations.

Ms. SCHNEIDER. Well, will the Commerce Department then take on the responsibility of coordinating the Federal efforts to promote conservation technology exports?

Mr. COLLINS. Well, no, certainly we'll work with them and the commercial attaches at the Embassies and of course—and that has been an integral part of this. But what we found out is, of course, that many of those attaches were trained before these renewable technologies and some of these conservation technologies were on line and they weren't discussed in business schools and other places like this. So we have spent some time in the educational process and No. 2, in the bill that—lead by Senator Hatfield in the Senate, Congressman Whitten and others in the House, the direction was put in the Department of Energy and we're pleased to have it as far as promoting renewable energy and, like I say, we think this is one of the two very exciting initiatives that we have in the renewable area this year.

Ms. SCHNEIDER. Great. One other brief question on the Residential Conservation Service. As far as I'm concerned that's one of the premier conservation and outreach programs that we do have that offers the least cost approach to dealing with our energy problems. And Secretary Hodel had indicated—former Secretary Hodel had indicated that the gas and the electric utilities are free now to terminate all of their Residential Conservation Service Programs. This really contradicts the 1983 CRF legal opinion that that statute require all Residential Conservation Service Programs to continue after January of this year. I'm interested in, you know, what action you folks are going to take based on—there was also a legal opinion from the DOE General Counsel, where are we in this situation now?

Mr. COLLINS. I think that, Ms. Schneider, that the DOE General Counsel's Office is working on that legal opinion to be sent up here. I think it will be midweek to late this week when that will be completed and we look forward to reviewing that with them and then of course, I assume subsequently members of this body. At the same time I'd say there's some exciting intiatives out—and we were concerned about the fact that some—we did a $1.7 million study and some of the RCS money was going to the upper-income individuals. And of course lower-income individuals in essence, had to pay for that to some degree by being included on the rate base. Initiatives like we have in Rhode Island and other States and where they've used petroleum over charge restitution funds. And of course the State has used shared savings programs, they have matched with State money, which is extremely exciting and I think it's the type of participation that we would want to get. The best participation that we got in any State in RCS was 20 percent and that was well beyond the next States, which were around 7 percent. So we do want to increase that participation and there may be a better way to pursue that as far as making it effective.

Ms. SCHNEIDER. Who is pursuing a better way of pushing that program?

Mr. COLLINS. Ms. Schneider, we have three pilot programs going last year that we're looking at, including banks and other institutions and of course, energy savings companies, as your plan did in Rhode Island. And I think that—and the program that Frank Stewart has, I think it is not—should not end with the low-income individuals, the 13 million homes that we have there. If—we hope that those who were involved will learn enough from it to use it in their own residences and in their own neighborhoods as well.

Ms. SCHNEIDER. So, if I were to answer a constituent today that was to ask me the question, what is the status of our program in Rhode Island, to be parochial for a moment, what kind of straight, honest answer could I give them?

Mr. COLLINS. Well, you included, I believe last year, like $200,000 in petroleum overcharge restitution funds and we have a bill in, which will—would keep, I think, funding level, for example, that we have had, we put in for a 5-year program at a steady funding level last year. We're working on legislation very similar to that next year. No. 2, you added the State part, which I think is very important. Then in essence that was a match with the Federal, although it wasn't called that per se. I think there was $75,000 from the State, $100,000 in the Federal program. I think all those types of creative programs can be—will be able to be pursued, and very effectively in the series—in a series of pilot programs—as a result of a series of pilot programs that we had last year.

Ms. **Schneider**. Well, I thank you for your very direct, straightforward testimony. It is a pleasure being a member of this Staff and having the knowledge that I can sleep well tonight knowing that you are at the helm of handling many of these programs that I care a great deal about, so keep up the good work and thank you for your direct testimony today.

Mr. **Collins**. Thank you, Ms. Schneider.

Mr. **Walgren**. Thank you, Ms. Schneider. The Chair recognizes the gentleman from Ohio, Mr. Traficant.

Mr. **Traficant**. Thank you, Mr. Chairman. I'm quite concerned about the Department's priorities as it relates to the steel industry, which has sort of been decimated in this country. I come from a region, the Youngstown area—Youngstown, Ohio—where steel is one of the great concerns that we have. I'm wondering what are the Department priorities as far as the steel initiatives are concerned and some of the activities of the American Iron & Steel Institute?

Mr. **Collins**. Mr. Traficant, as you know this was begun in 1983, by Jay Keyworth, the President's Science Adviser. Just this year we have committed, in the Department of Energy, through the basic energy research, about almost a million dollars in three different aspects of that program. Some of the work that we are doing in the conservation area of the Department of Energy certainly is very similar although there is somewhat of a continuum there between basic research and that which I think is closer to the industry, but I think there are several things that we can look at and pursue that are very similar to what we are already doing and also tie that into the basic energy research program work and try to provide a realistic package to assist the industry.

What Al Streb, I think, pointed out earlier is what we have been doing in the thin strip casting, which we're excited about the possibilities of assisting the industry, and as far as the initiative goes I think there are so many things that are very close. Although there is a little distance there, but that we can work out a—hopefully, some programs that are very realistic and very helpful to the industry, which I think we're all sensitive about or should be.

Mr. **Traficant**. I think what I'm concerned about, what is the priority that's placed on the steel industry, from your focus and your programs that are available? What type of turnaround, perhaps, could be expected if we had more of a priority? What is your feeling in regards to the priorities the Department is giving to that problem?

Mr. **Collins**. Mr. Traficant, I'd like to say that I didn't spend more time on any one contract issue last year than I did on the thin strip casting of steel. A very highly competitive process. And we're very pleased that we were able to pursue two avenues as well. We took some funding out of the Department's regular appropriation and pursued a second avenue, which most people would say was a little bit higher risk, but we wanted to see if there was a possibility in that area. The million dollars that we have in basic energy research, we think will support that. I don't think that that's necessarily the end and I would like to ask Mr. Streb if he could elaborate on that a bit.

Mr. STREB. With respect to our current program in the Office of Industrial Programs, the current request is something on the order of $35 million. I think if you look at the details of that you'll find that quite a large percentage of that—of the total—applies to the steel industry either directly or indirectly. We've been sensitive for many years as to the needs of the steel industry, first of all the opportunity that exists in the steel industry for energy savings, and it is one of the largest energy users taken as a group, and for that reason, of course, I've given it a great deal of attention. We've worked through the years, and particularly the last 2 years, working very closely with industrial representatives, working through the trade association, as well as with individuals, to identify areas of technology in which our program could not only contribute to our objectives, that of saving energy, but also contribute to the needs of the steel industry and I think we have quite a successful program as a result.

Now, you should not limit the—your thinking of our program, relative to the steel industry, to that of thin strip casting. It goes well beyond that. We have a number of sensor technology programs, which are underway, which are in direct support of the industry and specifically, in fact, identified by the industry. One is in situ analysis system that enables the industry to make online measurements of liquid metal as to the composition. There is a system for making temperature measurements of solids, and others which were efforts mounted specifically in the interests of the steel industry. High temperature steel heat exchangers for recovering heat from various steel operations we have about a $2 million effort in that area in fiscal year 1986. Though it is not specifically oriented to the steel industry, that's the primary ultimate user.

Last year, working with the industry, in collaboration with the State of Minnesota and the AISI, who were major contributors, we supported a test, a short campaign of 2 weeks, on a direct ironmaking process, actually a process developed in Germany by Voest Alpine in Kehl, and Korf Engineering in West Germany. We—this consortium actually shipped American ore, American coal, we ran for 2 weeks on that process, to prove that American products could be successfully run through that. We see that, or something very similar to it, as a solution to one of the problems of the industry and that is that much of the equipment, in terms of basic iron making, is very large. It has to be operated at full capacity. It can't be turned down, whereas this particular process can be made both small, economically and can also be modulated to suit the demands of the industry.

So, you see we've had through the years, and particularly the last couple of years, a very aggressive program.

Mr. TRAFICANT. One other thing is this—how's the work conducted on the thin slab and thin strip casting, those activities, how have they been related to the so-called Keyworth steel initiative? What is developing in those areas?

Mr. COLLINS. Al, you want to go ahead? Go ahead, Al.

Mr. STREB. The—I'm familiar with the Keyworth initiative and basically the report, which was generated in September, as a result of the work in Argonne, addresses two areas, one of which is direct iron or steel making, meaning basically bypassing a blast furnace coke oven battery and the other is near net shape casting of steel. The approach that we have taken on the latter, which is the thin strip casting, is basically to identify—take processes which have been identified and select those which we think are the best candidates and to pursue those through some state of development. The Keyworth approach is much more generic, as I see it. I think that's the way it would be best characterized as beginning with a better understanding of basic fundamentals and is not limited, as I would read it, to just the casting of thin sheet, but also direct casting to near-net shape of other shapes that are required for the industry.

It would be, I think, in summary, that effort tends to be broader, and more fundamental than the programs that we support with OIP.

Mr. TRAFICANT. Mr. Collins, how would you compare the efforts that are being made to try and aid the American steel industry to become more competitive and gain a little bit more of the market, which we've lost? It seems like we've helped these other nations, these other countries, mobilize the steel industry and now they sort of control it and we're second best. How do you rate the research and development efforts that are being made in your Department to try and help our steel industry in America come back? What have some of these other countries done compared to ours?

Mr. COLLINS. Mr. Traficant, I think that, of course, it's a multiagency approach to this in our Government and there is many—there is work being done in Commerce, obviously tax, Treasury related type work, which is very, very important here. But, as far as our Department, we've gone out and actually our work has been driven by the suggestions of the industry. And although we generally say that we are reserving Federal funds for basic and applied research in those technologies that probably are high risk and long term, this is the closest we come to an exception, I think, is in the steel industry, where we are extremely involved with the industry. Our research is probably more near term for that industry than in any other area, in the Department of Energy anyway, and so from that standpoint, I think that probably it would be more appropriate for people from the—that represent the Department of Commerce and the Treasury and others to talk about the overall assistance package and trade and other aspects, but as far as the Department of Energy is concerned, I don't know of a more near term orientation that we have with any industry like we do with the steel industry.

Mr. TRAFICANT. Well, I thank you, and thank you, Mr. Chairman. I thank the testimony I've heard here and some of the information that we've gotten about the steel industry. Thanks a lot.

Mr. WALGREN. Appreciate the gentleman's interest. It's a most central subject and one we want to encourage you very directly in. The Chair recognizes Mr. Cobey.

Mr. COBEY. No questions.

Mr. WALGREN. And then the Chair would recognize Mr. Bruce.

Mr. BRUCE. No questions.

Mr. WALGREN. Let me just ask quickly, the Ocean Thermal Energy Conversion area, you're reducing that by $1 million from something in the range of $4.5 to $3.5 million.

Mr. COLLINS. Yes, sir.

Mr. WALGREN. What's the rationale for that reduction? What progress have we made in that area? And what do you see its potential?

Mr. COLLINS. Well, I'd say that basically we're pursuing the four major areas of interest. In the environmental area we think that probably that's pretty site specific at this point in time. We've learned the general environmental difficulties that are involved with that and in the wave energy aspects of the Ocean Thermal Program. We do have—there is some work being done with one of our foreign partners in which we hope to get some research out of that, so that we will not have to fund that at the level we have funded before and that's the major difference in our budget, pursuing those four areas.

I'd like to ask Dr. Bob San Martin, the head of our renewable program, to talk about the potential there and also the success and the challenges that we've had in that research program, if I may.

Mr. WALGREN. OK. Just to underscore, the $1 million savings comes from increased contributions you anticipate from foreign partners?

Dr. SAN MARTIN. Mr. Chairman——

Mr. COLLINS. Them taking over part of the research in the wave area and then also from their conclusion that the environmental research is more, at this point, has been concluded in the generic sense and it's probably site specific in that sense, Mr. Walgren.

Mr. WALGREN. Dr. San Martin.

Dr. SAN MARTIN. Mr. Walgren, if I could expand on that. As Mr. Collins stated, we have a cooperative effort underway internationally in conducting some research and development in wave power devices. In that way of being able to cooperate extends our resources and will still make whatever knowledge is developed available to all of our industrial base. In addition to that, we have been conducting a number of environmental studies in support of all types of ocean energy technologies, and we believe that a very good national data base has been established for all of the generic types of considerations of the environmental type and that any future needs in environmental data in support of this resource, will be so site specific that it will, in fact, need to be developed on a project by project basis. And as the industrial base finds itself in the position to go forward, we'll, of course, extend to them all of the knowledge that has been developed in that area.

Beyond that particular point, all of the other activities that we have in the Ocean's program are proposed to be sustained at basically a level—resource level in comparison to the work that's being undertaken in 1985. I think that there has been a substantial amount of progress in this particular area in characterizing and beginning to understand that resource, especially the one that can be extracted from the ocean thermal types of concepts. We have a unique laboratory in the world that exists on one of the islands in Hawaii, and we expect that work will continue in that area also.

Mr. WALGREN. All right. OK, well are there further thoughts from members of the committee?

With that let me express our appreciation as a committee for your availablity and your making yourself available as a resource to us in our work. We appreciate your cooperation very much.

Mr. **Collins**. Thank you very much, Mr. Chairman.

Mr. **Walgren**. The next witness is Dr. Hubbard, the director of the Solar Energy Research Institute in Golden, CO. If you would come forward, Dr. Hubbard.

I appreciate your being here, Dr. Hubbard, and let me say at the outset that your written statements will formally be made part of the record and available to us in the public as a resource outlining your views. Please feel free to outline and focus on the points which you feel are most important to underscore. Please proceed.

[The biographical sketch of Dr. Hubbard follows:]

Harold M. Hubbard, Director, Solar Energy Research Institute

Dr. Harold M. Hubbard was appointed Director of the Solar Energy Research Institute on December 15, 1981, after serving as interim Director since July 1981. He continues as Executive Vice President of Midwest Research Institute (MRI), the parent organization that administers SERI's contract for the U.S. Department of Energy.

Before assuming the directorship of SERI, Dr. Hubbard had general responsibilities for MRI activities at headquarters and main laboratories in Kansas City, and at MRI off-site research operations in Minnesota, North Carolina, Ohio, Washington, D.C., and Saudi Arabia. In that capacity, he served in a key management and operating role during the formative years when SERI was being organized to assume the nation's preeminent role in solar energy research.

Although he has relinquished his operational responsibilities at MRI in Kansas City to devote full time to the management of SERI, he continues his corporate involvement in planning and setting overall policies for MRI.

Prior to his present position, Dr. Hubbard was Vice President for Research Operations, responsible for management of MRI's Kansas City research division. He joined SERI's parent company in 1970 as Director of Physicial Sciences after spending 18 years with du Pont, 15 of them in supervisory and research management positions.

A research scientist during his early career, Dr. Hubbard received his B.S. degree in chemistry and his Ph.D degree in analytical chemistry with a minor in chemical engineering from the University of Kansas.

STATEMENT OF DR. HAROLD M. HUBBARD, DIRECTOR, SOLAR ENERGY RESEARCH INSTITUTE, GOLDEN, CO

Dr. **Hubbard**. Thank you, Mr. Chairman. There we are, now we're live. And I'll try to summarize briefly because you have a very crammed schedule this morning. Secretary Collins and his entourage have given you a good picture of what the national energy policy is as it relates to renewable energy and they have overviewed the program, so I don't propose to do that. I will be talking from a laboratory director's perspective as an implementer of the program and as a contributor to the scientific and technology base.

SERI, as this committee well knows, is the only DOE laboratory that is focused exclusively on solar energy technology and let me give you just a few brief comments on history. Public Law 93-473 set up SERI in 1974. It came into being as a result of a contract competition for a management contract in 1977. Early years were somewhat chaotic. There were some three directors in 4 years. There were significant shifts in funding and in the early period, when SERI was just coming into being, it was assigned a good many responsibilities that lay outside the basis of its research and development focus. SERI today is focused on solar energy research. The mission statement simply says that SERI is to be the Nation's primary laboratory for solar energy research and it is to perform functions assigned by the Department of Energy in research development and testing. That it should conduct and coordinate research on solar technologies, which private industry cannot reasonably be expected to do. SERI, with the support and cooperation of DOE, is moving toward becoming the centerpiece in solar research. SERI appreciates that support and we're doing all we can to justify that and very significant progress is being made in the maturation of SERI as an institution. There is an outstanding and highly capable staff and I think the results and productivity of that staff are now becoming apparent. It is a broad and complex program. We have some four research divisions. We're involved in about 11 different programs. I think that's important because sooner or later decisionmakers in the private sector and the Government are going to have to make decisions among various renewable options. And to do that from an objective and informed knowledge base really requires, in my view, an organization that is broadly involved, broadly enough involved, so that informed technical judgements can be made across the entire spectrum of solar energy technology and my own advisory committee thinks that's an important function for SERI.

I recently became involved with the Energy Research Advisory Board supply panel, looking at the future security and nature of a mixed and diverse supply source for this country and in the process of doing that, reinforced my view that renewable energy and solar technology has a major role to play into that.

Time scale will depend upon a lot of factors, but if you look at the history of the development of energy technologies generally, you will find that from conception to first commercial practice is two to five decades, that from initial commercial practice into significant penetration in the market is often another two to three decades and so I think solar is in that kind of a posture. A posture in which the scientific and technological base is coming together, but in which it's going to be a significant period of time before its penetration into the energy mix of this country because of a large factor. During that period of time it's going to be necessary, in my view, that there be strong Federal support to the R&D program because generally speaking market opportunities that will ultimately be there are sometime removed in the future. So that the time scale for what is a weak and relatively emerging industry is such that one cannot reasonably expect that the industry, in and of themselves, can support the necessary R&D effort.

The 1986 budget, which you had asked me to comment on, in general, I think, supports, sustains and will maintain the basic structure and momentum that we currently have in the program. And I think that's important. If I now relate—switch back to what does SERI need, the thing SERI needs more than anything else, and it's something which I believe, based on Under Secretary Collins' statement and the support of this committee, we're beginning to achieve, is continuity and stability in the research and development program. Agreement reached and maintained on the support levels appropriate to the needs of the National Solar Research Program and consistent with present fiscal circumstances, will permit the program managers within DOE, within SERI and for that matter, within the industry, to do sound planning. It will permit effective utilization of resources and will provide the researchers with the stability they need to do excellent and pertinent research.

If you'll look at the fiscal year 1986 budget proposal with respect to SERI's needs, we have received the initial guidance from the Department. As you know, SERI is not a line item in the budget. Its budget is an aggregation or roll up of sections of the budgets for the various technologies and initial guidance we have received will maintain SERI's research activities at a reasonable and productive level. There will be some changes. We would see SERI's work on PV being—photovoltaics, being somewhat strengthened. Same would be true with respect to the wind program. Present guidance would indicate that our research in biofuels and our research in solar buildings might be somewhat weakened, but the details of that are yet to be worked out.

In the administration proposal, as it went forward to you, there was for the first time, significant funds, roughly $2 million devoted to the upgrading of SERI's facilities and on general plant equipment and general plant project funds. That is very important to us and we're happy to see that and we hope that that can be sustained.

In my statement, I give you more detailed information on the various programs at SERI, some of the accomplishments, some of our concerns, and with that, Mr. Chairman, I'd be glad to try to answer your questions.

[The prepared statement of Dr. Hubbard follows:]

TESTIMONY OF DR. H. M. HUBBARD
DIRECTOR
SOLAR ENERGY RESEARCH INSTITUTE

BEFORE THE
U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY
ENERGY DEVELOPMENT AND APPLICATIONS SUBCOMMITTEE

March 5, 1985

Good morning, Mr. Chairman and members of the Subcommittee. My name is H. M. Hubbard, and I am the Director of the Solar Energy Research Institute. I appreciate the opportunity to testify here today at these hearings on the Fiscal Year 1986 budget authorization request for the Department of Energy's programs in Conservation and Renewable Energy. Under Secretary Collins has just reviewed these programs and their budgetary needs from a national perspective, relating them to the goals of our national energy policy and outlining the activities and accomplishments expected in each major program area. I will address the topic from the perspective of a DOE laboratory fully committed to generating the science and technology necessary to realize the potential of these programs. I want to take a few minutes first, however, to review the history of SERI to set the stage for describing our view of the present and future in the solar field.

THE SOLAR ENERGY RESEARCH INSTITUTE - HISTORY

As you may know, SERI was established by Public Law 93-473 in late 1974 to enhance the contribution of solar energy to our national energy resources. Section 10. (a) of this document states in part, and I quote:

> "There is established a Solar Energy Research Institute, which shall perform such research, development, and

> related functions as the Chairman may determine to be necessary or appropriate in connection with the Project's activities under this Act or to be otherwise in furtherance of the purpose and objectives of this Act."

The term "solar energy" was defined in the Law as:

> Energy which has recently originated in the Sun, including direct and indirect solar radiation and intermediate solar energy forms such as wind, sea thermal gradients, products of photosynthetic processes, organic wastes, and others.

Responding to this challenge, the Energy Research and Development Administration (ERDA) conducted a competition to select a management contractor; the organization chosen was Midwest Research Institute of Kansas City, Missouri. SERI began operations in July 1977, as a national center for solar research and development.

The language of the Law is flexible and in its first several years of operation the Institute performed work in many areas peripheral to the research and development focus now emphasized. Thus, SERI was involved in market and policy-related studies, including policy and program planning, management of international solar programs, socioeconomic and environmental studies, public information dissemination, and projects designed to accelerate the commercialization of solar technologies - carried out in addition to major R&D program and subcontract management responsibilities.

Major organizational changes were implemented during 1981-1982 to focus attention on scientific and technical research with potentially high return. Restructuring to emphasize the research mission substantially altered the needed skill mix of the staff and the facilities needs of the laboratory. Since that period of redirection SERI has, with the support of the Department of Energy, entered a period of relative stability in both its mission and in the level of support it receives. We have strengthened our management and staff, increased our research productivity and, generally, focused on the maturation of SERI as a research organization.

SERI began its operations in leased facilities but in late 1981 DOE acquired title from the State of Colorado to a 300-acre permanent site near Golden. Construction began in 1982 on a field test area and a supporting laboratory building. The 70,000 square-foot building includes high bay and specialized laboratory space and accommodates 60 researchers and support staff. It was completed and occupied in 1984 and formally dedicated last month. The bulk of the Institute's staff remain in leased facilities at the Denver West Office Park, which is near the permanent site. SERI presently has approximately 200,000 square feet under lease, at a total annual cost of $3.4 million. Several of these facilities, although designed as offices, are being used for laboratory space. This has resulted in some fundamental design inadequacies and limited flexibility. Even so, our operations in these facilities are reasonably safe and laboratory productivity has been good. Overall, we feel that SERI is making substantial technical progress and is achieving considerable recognition as a sound and innovative research organization from both the scientific community and the industrial sector.

SERI - THE PRESENT

SERI has been the beneficiary of close attention and continuing support by the DOE. The potential of solar energy and the importance of SERI's role in its development are clearly recognized in the recently revised mission statement for SERI which reads as follows:

> "To be the nation's primary federal laboratory for solar energy research and to perform functions assigned by the Department of Energy in research, development, and testing. SERI carries out its mission by conducting and coordinating research and development on solar technologies, which private industry cannot reasonably be expected to undertake. This work advances scientific understanding and establishes a sound technological base, enabling the private sector to make well-informed choices among technology options. General guidance is provided by the National Energy Policy Plan; specific direction is provided by year-to-year authorizing documents."

The focus explicitly stated in this statement of mission is on research, development and testing. I make special mention of this because it is worthy to note that SERI exists to pursue science and technology to speed the development of the solar resource; and to transfer that science and technology to the private sector for ultimate utilization by consumers. The goals of the National Energy Policy Plan IV to promote a balanced and mixed energy resource system at reasonable cost are fully supportive of this targeted mission. SERI is committed to leadership, excellence and innovation in solar energy science and technology. In so doing, it supports the national strategy to improve both energy supply and end use efficiency.

I am pleased to note that the DOE Office of Renewable Energy has made a substantial commitment to establishing SERI as the primary laboratory for this national effort to make available its solar energy resources. This has been reflected in increased responsibilities as well as in resources. Over the past three years, SERI has made rapid progress toward attaining the organizational maturity and status expected of the leading laboratory in its field.

The proposed FY 1986 budget will maintain the present solar research and development effort at a reasonable and productive level. As I will indicate later, what is needed is continuity and stability in the program long-term, i.e., five to ten years. Agreement, reached and maintained, on the support level appropriate to the needs of the national program and present fiscal circumstances, permits program managers to do long-term planning, leads to effective utilization of resources, and provides researchers with the stability to perform excellent, pertinent research.

In justification of this continued support, let me say that SERI is making outstanding progress toward its scientific and technical objectives. Its staff are creative and scientifically sound. Many of its scientists are already recognized experts in this "new" field of solar energy science. To describe the progress we have made even in an abridged way, I will need to go into some detail about how SERI is structured and the type of work it pursues.

SERI's activities complement and support the solar research activities and roles of universities, other federal laboratories and private industry. Approximately one-third of the Institute's annual budget supports research subcontracted to these organizations. In addition, SERI remains committed to strong interaction with the university community through a series of formalized research participation programs. The academic community represents a valuable source of new ideas and talents that can enrich the research breadth and depth and contribute to the ultimate transfer of the technology base resulting from SERI-managed research. The Institute's continuing academic and industrial involvement provides for cooperative research efforts through postdoctoral, sabbatical, and visiting professional researcher appointments, as well as through direct subcontracting. During 1984, SERI hosted 74 research participants from the university community and had more than 200 active subcontracts to educational institutions. At present we have, or are in the process of placing, nine subcontracts to Historically Black Colleges and Universities. In addition, we continue to have special solicitations for university research proposals.

The Institute is also working to strengthen its interactions with industry in order to foster the transfer of the scientific and technical knowledge base to enable the emerging private sector infrastructure to begin to make decisions focused on incorporating renewables into the energy supply network. Over time these decisions can enhance the nation's economic well-being, environmental quality, and energy security. This is being achieved through collaborations and subcontracts with industry. During 1984 SERI had more than 430 active subcontracts with small and large businesses. Scientists and engineers from SERI regularly participate in joint research studies with their industrial colleagues, sharing progress and results. We are developing a dialogue with industry on research objectives and discussion of results on a continuing, day-to-day basis.

Many of SERI's research laboratories and test facilities are unique. In keeping with DOE's policy to make its laboratories and facilities available to qualified scientists who can make the best use of these capabilities, SERI has identified several of its laboratory facilities for use by those interested in cooperative relationships among the federal laboratories, the academic community and private industry. These user facilities include: Photovoltaic Devices and Measurements Laboratory, Surfaces and Interfaces

Laboratory, Mid-Temperature Collector Research Facility, Heat and Mass Transfer Research Laboratory, Daylighting Laboratory, Mobile Wind Acoustic Noise Characterization Laboratory, Gasification and Pyrolysis Facility, and the Wind Energy Research Center.

To meet its research objectives SERI is organized into three major research divisions, a Research Support Division and appropriate management and administrative functions. The major research divisions are organized by energy product: Solar Electric Research, Solar Fuels Research, and Solar Heat Research. Research within these divisions supports nine DOE Conservation and Renewable Energy Program areas and DOE's Office of Energy Research (OER) Basic Energy Sciences efforts. The Institute's Development and Planning Office coordinates and integrates OER sponsored research and technology transfer efforts with the applicable area of research in the four divisions. Major research areas include:

- Photovoltaic Energy
- Wind Energy
- Biofuels (including Alcohol and Municipal Solid Waste)
- Solar Energy Storage
- Solar Thermal Energy
- Solar Buildings Energy Systems (Active and Passive Heating and Cooling)
- Building Energy Research and Development
- Ocean Energy Technology
- Basic Energy Sciences (including Chemical, Materials and Biological Sciences and Advanced Energy Projects)
- Solar Resource Assessment
- Solar Technical Information

SOLAR ELECTRIC RESEARCH DIVISION

The Solar Electric Research Division carries out advanced R&D in solar electric technologies including photovoltaics which is currently the largest single program at SERI. The Division is responsible for field management of the Photovoltaics Advanced Research and Development Program, the Wind Energy Research Center and Solar Resource Assessment activities.

SERI photovoltaics researchers investigate innovative concepts, materials, and structures to evaluate the technical feasibility of new solar cells. The objective is to advance scientific understanding and to establish a technology base for industrial use. SERI has built photovoltaic laboratories with an impressive array of advanced laboratory research equipment used for in-house research, collaborative research, and in support of subcontracted research. The Division's device and materials characterization capabilities are recognized as a unique and independent assessment resource unmatched by any single organization currently conducting photovoltaic research.

A thin-film cell of copper indium diselenide developed at the Boeing Aerospace Company under subcontract to SERI achieved an efficiency of more than 11 percent and was recognized by Industrial Research Magazine as one of the 100 most significant technological advances of 1984. Several companies have fostered amorphous silicon research and development programs based on the technology supported and developed by the Photovoltaic R&D Program. Theoretical modeling of new ternary semiconductor systems and their interaction with sunlight has identified a group of new materials which may have photovoltaic and other semiconductor properties useful to the electronics industry.

In late 1984, the Innovative Wind Energy Program at SERI was merged with the Small Wind Energy Conversion System Program and facility at Rocky Flats to form the Wind Energy Research Center, now part of the SERI organization and included in the Solar Electric Research Division. The Center was formed to emphasize research in aerodynamic, structural, and environmental issues for the development of wind technology.

SOLAR FUELS RESEARCH DIVISION

The Solar Fuels Research Division is responsible for field management of the Biofuels and Solar Energy Storage programs. Researchers apply the chemical and biological sciences along with the related engineering disciplines to develop new concepts for producing fuels. The Division conducts research and manages subcontracts in the production and conversion of biomass to fuels as well as the direct use of solar energy through photoconversion of low fuel value materials to higher fuel value materials. Typical project areas are new processes for converting biomass to fuel alcohols and for the production of oil from microalgae.

A result of this type of research is a SERI-invented pressurized, oxygen-blown, fixed-bed, down-draft gasifier that converts biomass such as agricultural wastes, wood, or municipal wastes into medium-Btu gas or synthesis gas for the manufacture of methanol or ammonia. A private U.S. firm was formed and has announced plans to market scaled-up versions of this 1982 IR 100 award winner, capable of converting 16 tons of wood per day to low Btu gas.

The Division has obtained scientific and industrial recognition through its work in photoconversion, electrochemistry, thermoconversion, and biotechnology. The Division's capability in basic research and its applications to innovative technology will strengthen the biofuels technology base and provide industry with new options for future fuels products and processes.

SOLAR HEAT RESEARCH DIVISION

The Solar Heat Research Division performs research in the areas of solar thermal processes and materials research. Solar thermal processes activities include active and passive heating and cooling systems; solar thermal technology, primarily for industrial and utility applications; building energy research and development; and ocean thermal energy conversion technology. SERI provides private industry with a center where research is performed and the results are used by industry to improve its products or expand its product line.

The objectives of the materials and supporting research activities performed in this Division are to identify and develop promising materials for solar thermal systems. These include research on materials for absorbing, transmitting, and reflecting solar radiation; materials for advanced structural support; and working fluids. This work also addresses research and development that private companies within this industry cannot readily support.

A major SERI accomplishment in ocean energy research is the development of a vertical spout evaporator concept that may be more than 70 times as effective as a conventional tube and shell heat exchanger in producing steam for an open-cycle OTEC system. This development was recognized in 1984 by Industrial Research Magazine as one of the 100 most significant technological advances of the year.

SERI - THE FUTURE

Recently I have had the opportunity to participate in a study by the Energy Research Advisory Board which has as its objective: "To develop judgments on the essential ingredients of a balanced, long-range energy R&D effort." I have been working with a panel concerned with energy supply. This panel includes representatives of the coal, oil, gas and nuclear industries, as well as members concerned with fusion, electricity and transportation and storage. We have explored the various options open to our nation for meeting its energy needs. This experience has convinced me more than ever that a vigorous program in renewable energy research and technology development is a vital component in our nation's future energy security. Why do I say this? Let me attempt to establish some perspective on this issue.

The National Energy Policy Plan IV, using conservative estimates of technology cost and performance, concludes that the quads of energy supplied by renewables will double between 1982 and 2010. Renewable energy resources in a very conservative projection are expected to provide 13 percent of our domestic energy supply in 2010. I believe this represents only the beginning of a broader adoption of renewable technologies in the marketplace. Why? Because the projection assumes no substantial contribution from evolving solar technologies such as photovoltaics and only limited contributions from those now emerging such as wind turbines. It counts only the expected contributions of mature technologies such as low-head hydropower and conventional biomass.

The conservative nature of the projection reflects the long lead times to assimilate new technologies into the energy infrastructure of our economy due to existing capital investments, the capital-intensive nature of new capacity, uncertainties in growth of demand, and time necessary for the development of the management and technical expertise required by technological innovation. Nevertheless, the projected increase in penetration is substantial even though it does not fully recognize the potential of the newer solar technologies undergoing research and development today. Renewable energy is big and, in response to market demand addressed through a private sector/federal national R&D partnership, will grow bigger.

In order for the newer, developing technologies to become competitive in the energy market of the future, there are still many scientific and technical challenges which must be addressed to improve efficiency, lower costs and increase reliability and durability of renewable energy materials, devices and components. The development and energy production accomplishments to date illustrate the success of the collaborative research established between the Federal program, industry and universities. Today, a growing renewable energy infrastructure has emerged based primarily on the cooperative and supportive efforts of this partnership. An indicator of the remaining challenge in the various technologies is the projected (potential) cost of delivered energy. This provides the first indication of cumulative advances which are required in efficiency, reliability, useful life, and materials development. The table below highlights the current status of and future cost potential for energy for some representative solar energy systems.

Energy Type	Technologies	Current	Potential
Electricity	Wind, Photovoltaics, Solar Thermal	\$.10-1.50/KWH	\$.03-.15/KWH
Heat	Solar Thermal, Biofuels	\$3-10/MBTU	\$2-9/MBTU
Gaseous Fuels	Biofuels	\$8-12/MBTU	\$5-8/MBTU
Liquid Fuels	Biofuels	\$20-24/MBTU	\$14-20/MBTU

Solar research areas offering high probabilities for achieving such goals include development of:

- thin film, polycrystalline or amorphous silicon PV materials and cells
- multi-junction crystalline, solar cells using concentrated sunlight
- wood, herbaceous plants and municipal solid waste based conversion processes to produce quality liquid and gaseous fuels
- aquatic plants for production of feedstocks for liquid and gaseous fuel production
- lower capital cost and improved capacity factor wind machines

- a variety of unique building materials, such as variable transmission glazings, aperture and insulating materials, and advanced storage devices which will enable improved solar load control and enhance daylighting in passive and solar buildings

- advanced solar thermal systems, collectors, and receivers capable of operating at high temperatures and supporting very efficient power cycles

- new ocean thermal concepts leading to small scale plants capable of producing power and potable water.

I feel that success in all or most areas can be achieved over the next ten to twenty years, providing there is stability in the national program. In response to your specific concerns with respect to SERI's ability to fulfill its mission, the proposed FY 1986 budget would maintain our current level of effort, although there will be shifts among the various programs. As far as SERI's laboratory facilities are concerned, we can continue to operate in leased facilities; however, given the projected long-term nature of the solar energy technology development program and SERI's central role in it, I believe that it would be more productive for the nation to continue its investment in permanent facilities and phase SERI out of those it is leasing.

Meeting the scientific and technical challenges will only provide opportunities for our nation to utilize its renewable energy resources more broadly. As the following table from a recent International Energy Agency report shows, technology development to first commercial application typically takes 20-50 years; an additional 20-30 years is required to establish significant commercial use.

Historical Development Times of Six Selected Energy Technologies

Technology	Development Time to Commercial Application (Years)	Additional Time for Significant Commercial Use (Years)
Nuclear Power	16	20
Diesel Power	60	30-50
Pulverized Coal Combustion	25	15-18
Solar Heating (modern)	60	30
Low-Head Hydropower	50	20-30
Residential Heat Pumps	30	20

This implies that we will be at least another 10 to 20 years before these newer technologies achieve significant penetration in a competitive marketplace. I feel that strong federal support will continue to be necessary during this period to smooth the transition to the private sector and facilitate the penetration of the newer renewable technologies into the energy supply mix.

The potential benefits are very large. There is generally no question that we will need alternative energy supplies in the future; the questions are when and for which primary energy uses. If we are able to achieve the cost goals for solar technologies (and I think we can) the available resources base is such that I am convinced a significant portion of the nation's energy demand will be supplied by solar energy early in the 21st century.

Revisions made 4/10/85.

DISCUSSION

Mr. **Walgren**. OK. Thank you very much. Let me just go to the building question and ask you how important it is to you. You indicate it is important to you. As I understand it, the proposal is to move from some leased structures to some permanent facilities that would be owned, built new, is that correct?

Dr. **Hubbard**. That's correct. Let me summarize for you what our present situation was. SERI started in 1977 and it started at leased facilities at a Denver West Office Park. SERI was located in Golden Place because the State of Colorado, at least one of the factors was that the State of Colorado made available—at no cost to the Government—to the Department, a permanent site for the solar research facility. Title to that site, which consists of about 300 acres on South Table Mountain, was transferred to the Department in 1981 and development of that site, in the form of a field experimental test area and subsequently in the authorization to proceed with a field test laboratory building in support of that area was begun in 1982 and that building was completed in 1984 and was dedicated last month. That is a specialized facility primarily devoted to research in the general area of biofuels, has permitted us to vacate leased facilities that were, to be blunt about it, strung around in a series of garages around Golden. And it will be a very effective and a very helpful building.

Over and beyond that, the bulk of our research staff—and we have permanent staff, about 500—continues to be housed in leased facilities in Denver West. There is a major converted office building, which is our major laboratory building. We're doing productive work in that building by modifying the building, making substantial Government investment in that building. We've increased its safety factor so that I'm reasonably content with the safety in the building. Nevertheless, it is not flexible in doing research in that in the sense of difficulties in moving experimental facilities around is essentially high cost and we pay a penalty in efficiency for that. We have discussed with the Department, and with the Department's support, worked out tentative plans for a site development process, in which the next initial step is a SERI reseach building. Preliminary design for that, carried out by the Department with our support, was—preliminary design is the wrong term. Conceptual design has been completed in the last 2 or 3 months and is now gone forward to the Department for consideration.

Mr. **Walgren**. There's new money in this budget for what in buildings, as submitted?

Dr. **Hubbard**. The money in the budget, as it went forward, is for general plant projects. It is not directly for building and construction. It is primarily to put in monitoring stations to take care of the required environmental monitoring on the permanent site and to extend and further develop the field experimental test area.

Mr. **Walgren**. I see. How much is to extend and further develop the field test center?

Dr. **Hubbard**. Approximately $800,000 of the $2 million.

Mr. **Walgren**. $800,000 of the $2 million?

Dr. **Hubbard**. As we have planned and as we sent it forward to the Department, yes.

Mr. Walgren. So $1.2 million is for—to meet Federal requirements as——

Dr. Hubbard. No, I wouldn't—it's more complicated than that. There are problems relative to upgrading of facilities in the Field Test Laboratory building. For example, we have problems with the stability in the electrical supply and that interferes with certain of our sensitive equipment. I don't remember the numbers off my head, but it takes about $50,000 to do that. There is further development—development of the roads for the Field Test Laboratory and so on was not included in that $800,000. I think the monitoring—and I can submit the actual figures for the record later on, if you'd like to have them—is something on the order of $350,000.

Mr. Walgren. I see. The reason this is such an issue is that there are other cutbacks in other laboratories that are painfully felt and it's of course difficult at that point to balance increased effort in other areas. We have to be very certain we have a record to justify that.

The Chair would recognize Mr. Packard.

Mr. Packard. Thank you, Mr. Chairman. You indicated that the proposed budget is essentially the same as this year's budget for 1986?

Dr. Hubbard. The preliminary guidance for the Solar Energy Reseach Institute in the aggregate is the same, yes, Congressman.

Mr. Packard. And your current level of staffing is at 500, I think you indicated. Will you be maintaining essentially the same staff levels?

Dr. Hubbard. Given current guidance I think we would have a slight reduction in current technical staff.

Mr. Packard. And do you perceive——

Dr. Hubbard. Although it balances out, it's within the allowed level.

Mr. Packard [continuing]. You perceive SERI generally as in a growth mode or in a stabilized mode at the levels we now see it as far as the line——

Dr. Hubbard. I see it essentially in a stabilized mode. Now, there have been issues within the Department to consolidate the field structure and in the process of that responsibility has been moved to us. For example the Wind Energy Research Center, which was a responsibility of Rockwell International on the Rocky Flats site and is about 15 miles from us; that has been transferred to us and when it was transferred to us the majority of their staff came along with it, so we see some aggregation of staff as we pick up existing responsibilities. We do not see an expansion of staff, although one of the things we have been doing as we improve our own internal management systems, is to reduce the amount of our administrative and service people and use those funds and that improved efficiency to increase the funds devoted to research, both in the form of increased outside subcontracting with industries and universities and in the form of judicious strengthening of our own research staff.

Mr. Packard. How do you, in your organization, interface with DOE. Under—who do you report to and what is the general structure of your organization?

Dr. Hubbard. Complicated issue. I sometimes wonder why I need so many bosses, but generally it works like this—and it's a constructive interface, I should add—there is an area site office on our premises and the contracting officer and the area site director works with me on a day-to-day basis on programmatic, administrative, and financial issues. He, in turn, reports to the manager of the control operations office. Simultaneously with that I work very closely with the office of the Assistant Secretary of Conservation and Renewable Energy; primary contact there is Dr. San Martin, and to a lesser degree, because we do less work for them, Mr. Streb.

Mr. Packard. Thank you very much, Mr. Chairman.

Mr. Fuqua. Mr. Traficant.

Mr. Traficant. Thank you, Mr. Chairman.

Dr. Hubbard, how are you doing today?

Dr. Hubbard. Not bad, I hope.

Mr. Traficant. Yes, you're doing real well out here. My concern is we have a major university in my area and I was wondering how much money, in this next year's budget, goes to colleges and universities, from SERI, for research purposes?

Dr. Hubbard. You know the number I will have to dig out and submit for the record. We have a rather large program and it's run through—as a component of the individual technology programs with universities and let me refer to my testimony because I think in that there are numbers on the number of contracts that we have with university participates—19, and let me reiterate that.

Mr. Traficant. Yes.

Dr. Hubbard. 1984, SERI hosted some 74 research participants from the university community. We had about 200 active subcontract to educational institutions.

[The information follows:]

Information on SERI Subcontracts to Academia Institutions

Complete information is available for FY 83 and FY 84 (see below). Current projections suggest that FY 85 and FY 86 will be roughly the same as the preceding years.

	Fiscal year—	
	1983	1984
Active subcontracts to academic performers	81	65
New subcontract awards	43	52
Subcontract dollars awarded	[1] 6,267,000	[2] 8,495,000
Total subcontract dollars	16,453,000	18,419,000
Number of states receiving at least one award	18	19

[1] 38 percent.
[2] 46 percent.

Mr. Traficant. How does SERI or how do you determine the capabilities of those universities? What is the major criteria for selecting them under these respective programs?

Dr. Hubbard. We network, as is customary in the scientific and technical community. Our scientific and research staff maintain constant contact with the leaders in their research field. So, we are generally relatively knowledgeable about where the capability lies.

In the process of our networking and in the various conferences and discussions we have, the university researchers very often come to SERI to participate in our research conferences. The purpose of that is so that we have a sense of their capability and they have a sense of what our needs are. SERI does not have the authority to make research grants. We do have the authority to grant subcontracts. Those are normally competitive procurements. Under some circumstances noncompetitive sole-source procurements are possible, if there is adequate justification for that as judged by both our research staff and our legal staff.

Mr. TRAFICANT. What is the current activity in the State of Ohio that you're involved with, if any?

Dr. HUBBARD. At the universities, I would have to review that and see where we are. We have a lot of contact with the NASA Wind program in the State of Ohio.

Mr. TRAFICANT. Just in closing, how do you rate the research in solar energy in making it a viable component to the energy needs of the country? How do you rate its progress, from your position, in the last several years?

Dr. HUBBARD. I am pleased about the scientific and technical progress. I think as the research has gone forward we have discovered that we do not know as much about solar technologies as we need to know in order to be sure that the technologies are developed and in place and are in fact going to work and are viable. So, that in the last 3 or 4 years, as the emphasis at SERI and within the program has changed and begun to emphasize the underlying basic and applied research problems that underlie the technology, I think we can begin to understand that a lot better. Let me give you a couple of examples: In the photovoltaic area where both the science and industrial capability has made a lot of progress, the industry is primarily working on innovative components and production capabilities. What they do not have the ability to do, and what they continually ask us to do, is to identify and work on the underlying scientific problems that are limiting the efficiency and inhibiting the development of low-cost material, so we have a scientific and technology review committee, which has both university and industrial people on it, to advise us on the nature of that program. Another example that surfaced in Secretary Collins' testimony was the Wind program. We have discovered, as machines were put into place, that the aerodynamics and structural dynamics of wind machines is much more complicated than originally anticipated. I think it was originally thought that if we took the technology of the 1940's and if we took what we knew from helicopter technology and applied that to wind turbine design, the things would work. That's what was done and they don't work well.

Mr. TRAFICANT. One other point. How much more use and utilization of solar energy have you seen in the general consumption of the American public, in the consumer? How much more is practically being utilized to offset some other energy problems and our dependence on other nations for our energy?

Dr. HUBBARD. At this point in time the biggest impact from solar technology has been, I think, in buildings design, where it has been really significant. Also, if you look at biomass utilization, biomass derived fuels, that has become significant. I think you'd have to say that the aspirations that many people who took a very positive view on solar technology in the mid-1970's had, that it was going to emerge rapidly, have been disappointed. Why? Because they were predicated on continuing escalation of oil prices, which has not happened. They failed, I think, to account for the impact of a true conservation effort on American industry and the conservation behavior of the American people and they overestimated the effectiveness of our current technology base. If you look out a decade to two decades, however, and project what the energy contribution potential for solar is, and like all numbers, when one begins to talk about energy reserves they get to be highly speculative, but in an order of magnitude sense they're valid, some estimates have been recently made within the Department that if you could conceivably provide something like 80 quads of energy from renewable sources by 2010. That's 80 quads on an anticipated 100 quad base. Now, nobody expects that to happen, but it simply says that the potential for penetration and large contribution is there.

Mr. **Traficant**. Fine, I appreciate your comments and I wish you well.

Dr. **Hubbard**. Thank you, sir.

Mr. **Fuqua**. Mr. Cobey.

Mr. **Cobey**. No questions.

Mr. **Fuqua**. Thank you very much, Dr. Hubbard. We appreciate your being here today.

Dr. **Hubbard**. You're welcome, Mr. Chairman; thank you for the opportunity to appear.

[Questions and answers for the record:]

Solar Energy Research Institute,
Golden, CO, May 13, 1985.

Hon. Don Fuqua,
Chairman, House of Representatives,
Committee on Science and Technology, Washington, DC.

Dear Mr. Fuqua: I am pleased to provide you with the following statements in response to your letter of May 2, requesting additional information relative to my testimony of March 5, 1985.

1. You say that "The proposed FY 1986 budget will maintain the present solar research and development effort at a reasonable and productive level." How does SERI's FY 1986 estimated funding level compare with this year?

Preliminary budget guidance for SERI from DOE for FY 1986 indicates a modest increase in funding compared to 1985 due to increased program responsibilities. The increase is primarily expected to be in funding for the wind program, although photovoltaic funding is expected to increase as well.

2. What is SERI's current staff level? Will you be able to maintin this level with the FY 1986 budget as proposed?

At the end of March, 1985, SERI staff consisted of 476 regular full-time employees, 9 part-time and 27 temporary employees for a total of 512. We expect to maintain this level in 1986 with the staff numbering between 510 and 530, depending upon final guidance.

3. You say that you "believe that it would be more productive for the nation to continue its investment in permanent facilities and phase SERI out of those it is leasing." What sort of additional permanent facilities do you have in mind, and what is the estimated cost?

SERI's primary laboratory research facility is a leased office building adapted to use as a research laboratory. For sometime we have been planning with DOE to replace this makeshift arrangement with a building designed for laboratory solar research, constructed adjacent to the field test facilities on our permanent site. The building will accommodate all of the experimental work currently being carried out in leased facilities in the Denver West Office Park and is estimated to cost $16 million. Our administrative and support services will remain in leased quarters in

Denver West for the foreseeable future. To move them would require an additional building of comparable or slightly larger size than the planned laboratory building.

4. Given the expertise that resides in existing DOE laboratories and the severe financial stresses some of the other laboratories, such as Argonne are facing, why should we make investments to expand facilities at SERI?

As indicated in (3) above, we are not proposing the "expansion" of SERI facilities, but rather the replacement of existing leased facilities with permanent facilities designed to be more efficient and cost effective for renewable energy research.

5. Is SERI's current level of staffing adequate for the foreseeable future to conduct a vigorous program in renewable energy research and technology development? What do you believe to be the optimal size for SERI?

SERI's present staff level is adequate for carrying our current assigned program responsibilities. Projected changes in the programs may require some changes in staff mix and the addition of a few carefully selected individuals as indicated in (2) above. No major change in staffing level is anticipated. Any additions that are made will be in the research and program management areas.

Please do not hesitate to contact me if you should need further information or clarification.

Sincerely,

H.M. Hubbard, *Director.*

PANEL I: PHOTOVOLTAICS AND RENEWABLES

Mr. **Fuqua**. We now have our first panel on photovoltaics and renewables and our members of that panel will be Prof. Henry Ehrenreich, Mr. Mark Anderson, Dr. Donald Klass, and Dr. Michael Berger.

Mr. Ehrenreich, if you will proceed and we'll hear from all the panel and then we'll have questions for all of you. If you have prepared statements you wish to summarize——

Mr. **Ehrenreich**. Yes.

Mr. **Fuqua**. And then you may summarize.

[The biographical sketch of Dr. Ehrenreich follows:]

Henry Ehrenreich, Harvard University

BRIEF BIOGRAPHY

Henry Ehrenreich was born in Frankfurt, Germany and has lived in the United States since 1940. He received the A.B. degree from Cornell University in 1950, spent one year at Columbia University, and subsequently returned to Cornell where he received a Ph.D. in Physics in 1955.

After eight years as a research member of the General Electric Research Laboratory (now called the General Electric Research and Development Center), he joined the Division of Applied Sciences at Harvard University in 1963 as Gordon McKay Professor of Applied Physics. In 1982 he became Clowes Professor of Science. He has been Visiting Professor of Physics at Brandeis University, the University of Paris, and the University of Pennsylvania. He has also acted as a consultant to both agencies of the U.S. Government and private industry on matters dealing with solid state physics and technology, metallurgy, semiconductor electronics, and optics. In 1984 he received the Metallurgical Society's Hume-Rothery Award "in recognition of his outstanding scholarly contributions to the Science of Alloys".

His fields of research are centered around theoretical condensed matter physics and include work on the electronic properties of semiconductors, metals and alloys, the magnetic and optical properties of solids, and the many-body problem. He has published extensively on these subjects. He also edits (together with D. Turnbull) a series of monographs entitled "*Solid State Physics*" published by Academic Press.

He is a Fellow of the American Physical Society, the American Academy of Arts and Sciences, and the American Association for the Advancement of Science. He was Chairman of the White House sponsored American Physical Society's Study Group on Solar Photovoltaic Energy Conversion. He has also served on the Department of Energy's Solar Photovoltaic Energy Advisory Committee and most recently on the White House Senior Scientific Panel on Indo-US Scientific and Technological Cooperation.

He has been Director of Harvard's Materials Research Laboratory since 1982.

STATEMENT OF DR. HENRY EHRENREICH, CLOWES PROFESSOR OF SCIENCE AND DIRECTOR, MATERIALS RESEARCH LABORATORY, HARVARD UNIVERSITY, CAMBRIDGE, MA

Dr. EHRENREICH. Thank you, Mr. Chairman. I am Henry Ehrenreich, the Clowes Professor of Science at Harvard University and director of Harvard's Materials Research Laboratory. My expertise in photovoltaics derives from the chairmanship of the American Physical Society/OSTP Study on Photovoltaics in 1979, and since, the service on a number of committees dealing with solar energy problems.

I would like to place what I have to say concerning photovoltaics into perspective relative to the overall energy problems confronting this country. The United States is a large scale consumer of energy. It contains 5 percent of the world's population and consumes 25 percent of the generated energy. However, since 1973, the oil crisis, there has been an overall reduction in the energy to GNP ratio, by about 25 percent due in large part to conservation. The same is not true for electrical consumption, which is now increasing at previous rates. The present excess capacity for generating electricity must therefore be regarded as temporary. The United States is still vulnerable to international political instabilities despite the present oil glut. Our oil production covers only transportation needs. Thus, all promising alternative energy sources, including nuclear, require consideration.

I have been asked to focus on the development and prospects for photovoltaic science and technology and to provide an assessment of problem areas and R&D needs. At present more than 75 percent of PV production involves single crystal silicon cells. It is questionable whether electricity costs involving this technology can be made requisitely low. Thin films, on the other hand, while in a far less developed state, do provide hope for low cost solar cells. The optimal thin film technology may involve materials that are amorphous, crystalline or a mixture. It is questionable whether the form of amorphous hydrogenated silicon used at the present time is optimal.

Fundamental understanding will undergird the progress in photovoltaic technology. The experience obtained in the development of highly sophisticated semiconductor devices used in the computer and optical communications industries would be useful in the understanding of solar cells through the studies of prototypes. Multilayered structures obtained with the help of sophisticated fabrication techniques will be used in cell utilizing concentrated sunlight that may have efficiencies far higher than any presently achievable. Further exploration of the structure/electronic property relation in glassy materials like amorphous hydrogenated silicon is required. Crystal growth mechanisms, including mathematical modelling of silicon ribbon growth require further understanding. A study of the electronic properties at all relevant interfaces where semiconductors is joined to other material is of great importance. Some of these matters indeed are crucial to the continuing progress of the entire semiconductor in this country and its supremacy.

Where is the emerging photovoltaic technology headed? Although the point is arguable, it is my view that photovoltaics will involve some form of silicon. Since a technology establishes its basic direction early in life, it appears likely that silicon, the mainstay of the semiconductor industry for some 25 years, will be as ubiquitous to photovoltaics as the internal combustion engine is to automobiles. Requisitely cheap materials will involve thin film cells or possibly concentrators. Tandem cells, that is, slightly differing, but cheap thin film silicon materials making photovoltaic cells that are placed on top of one another, in principle could produce much higher efficiency since they utilize a greater fraction of the sunlight. The results of this research have thus far been mixed. Cell efficiencies are still low. Research in this area, nevertheless, deserves substantial support because the rewards for success would be very high.

The sales of photovoltaic modules is growing very rapidly. They have increased with an annual growth factor of about one and a half and are projected to continue at this rate. Even the most conservative estimates of predictions covering a wide range of possibilities predict a substantial growth. By the year 2000 production may have achieved roughly half a percent of the 1982 U.S. utility capacity at prices competitive with intermediate power oil.

Let me conclude by stating or reiterating some problems presented and that are faced by photovoltaics. Crystalline silicon applications will probably be limited by cost considerations. Module prices are declining only slowly and many savings have already been realized. The criteria for utility applications are stringent and require highly efficient cells produced at much lower costs. The development time scales are far longer than those to which industry is accustomed. It is probably unrealistic to expect any significant penetration of the U.S. utility market before the first decade of the next century. The expiration of tax incentives, will lead to a serious diminution of industry interest. The absence of an energy crisis encourages a casual view towards alternative sources and surprising attitudes involving conventional supply; some of the present views, for example, concerning further enlargement of the strategic oil reserve are an example.

During the period just preceding 1980 many overstated promises were made. At that time a vocal and highly effective body of solar enthusiasts maintained that solar energy would be abundantly available in a short period of time. Many overreacted when these promises were not fulfilled.

Declining Federal support is hampering development of solar electric power. The planned fiscal year 1986 support level is too low, perhaps by 25 percent.

The problem of international market development requires attention. This is an intermediate market of considerable size, about $20 billion or more, involving minimal electrification in developing countries. This market will serve as a transition piece between the current speciality applications of photovoltaics and the much larger production that will accompany utility penetration in this country. This intermediate goal, achievable within a 10-year period, is likely to result in the requisite lowering of costs.

A more detailed and complete account of the points I've alluded to briefly here is in my written statement, which I trust will be entered in the record and I'd like to thank you for inviting me to come and testify and for your attention.

[The prepared statement of Professor Ehrenreich follows:]

PHOTOVOLTAIC TECHNOLOGY IN PERSPECTIVE*

H. EHRENREICH

Division of Applied Sciences, Harvard University, Cambridge, MA 02138

Summary

The development of and prospects for photovoltaic science and technology in this country are reviewed. Current perceptions towards the technology are optimistic but are tempered by the realization that the development of alternative energy sources does not represent a priority item during a period of energy stability. The growth of world-wide intermediate markets is a prerequisite for industry success. A far-sighted approach to technology and market development by U.S. industry and government is likely to result in appreciable national utility applications at the end of the first decade of the next century.

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*Statement before the Subcommittee on Energy Development and Applications of the Committee on Science and Technology, U.S. House of Representatives, 5 March 1985. A preliminary version of the author's views expressed here appeared in Solar Cells 12, 45 (1984). That paper includes references.

Photovoltaic technology in the U.S.A. is at a crossroad. While consistently improving technology has been steadily leading to promising industrial development, the temporary abatement of the oil crisis and the threat of eliminating tax incentives are inhibiting further development. This inhibition is deleterious to the national interest and effective long-range planning. Conservation has indeed produced life-style changes and appreciable reductions in the energy-GNP ratio. However, the present excess in electrical generating capacity is temporary: the electrical energy-GNP ratio is more nearly constant, leading to expectations of renewed electricity growth in the '90s.

The prospects for a large and profitable photovoltaics industry are bright, although the time scale for realizing profitability is longer than that to which industry is accustomed. The improvements in photovoltaics technology and manufacturing during the past 5 years have been impressive. This fact is often obscured by the attitudes that prevailed in 1978 when I served as chairman of the American Physical Society/OSTP Study of Photovoltaics. At that time a vocal and highly effective body of solar enthusiasts maintained that solar energy not only would solve the energy crisis but also would be abundantly available in a relatively short period. For example, the Council on Environmental Quality claimed that in the year 2000 over 20% of the nation's energy could be supplied by solar sources. This was to be accomplished in part with the help of government subsidies, deployment and a number of large-scale demonstration projects. Happily, many of these projects were never pursued. Considering the then premature state of the technology, much of this activity would have been wasteful. However, it is worrisome that the national concern for alternatives has largely disappeared now and the reliance on conventional energy sources has been reinforced.

The question of the federal role in the development of photovoltaics is important. The significance of such a role is perhaps underlined best by recalling that the growth of commercial aviation was accelerated because of government support for aeronautics after World War I and that the nuclear power industry evolved from federal interest in reactors after World War II.

The past few years have seen sound and evolutionary development of photovoltaics. The crystalline silicon technology, at present being emphasized in the U.S.A., has been improved by the manufacture of larger wafers, innovative processing techniques involving increased automation and better packaging of modules. Although we cannot be sure, it may well be that production techniques are now anchored to a "learning curve" with a highly respectable slope.

There have been some pleasant surprises. Amorphous hydrogenated silicon, which had a largely visionary appeal only 5 years ago, has achieved efficiencies on a laboratory scale larger than 10% and shows promise of turning into a major photovoltaics industry. Five years ago the photovoltaics community was not particularly enthusiastic about concentrators. Experience has since shown that tracking techniques are far more reliable and cheaper than had been thought. Heliostats are beginning to be used even for flat plates since two-axis tracking achieves 30% - 40% more output for a photovoltaic system in the Sun Belt region.

Sales in 1981 were about 5.5 MW_p world wide with a 3.5 MW_p U.S. contribution. Preliminary figures suggest a 1984 value of 20 MW_p. (Of this, about 20% is estimated to be associated with thin film amorphous silicon cells.) Sales have increased with an annual growth factor of about 1.5 and are projected to continue at this rate. By the year 2000, development may have achieved roughly 0.5% of the 1982 U.S. utility capacity at prices competitive with intermediate power oil. These figures are uncertain. The variations in various projections in 2000 amount to a factor of 20 and extend from about 500 MW_p for the conservative estimates to 12 GW_p for the optimistic estimates. Nevertheless, the six or so projections that were examined all agreed that there would be a healthy increase in production.

For the crystalline silicon technology the decline in price, although appreciable, has been considerably smaller than that originally projected. Indeed, many in the community question whether this technology can meet the stringent requirements demanded by utility intermediate power generation. As pointed out in the eminently reasonable proposed National Photovoltaics Program Five Year Research Plan (1984-88), some of the advanced thin film technologies, for example, amorphous silicon, may achieve these goals.

U.S. utility applications are more likely to involve systems larger than individual residences, perhaps tens of megawatts in size, because of large marketing, distribution, installation and interconnection costs. There is little doubt, however, that such installations will be far smaller than the 1000 MW central power coal or nuclear installations. Appreciable utility penetration 20 or so years from now must be preceded by intermediate-term applications. These will permit a steady and significant growth of the industry, improvements in technology and the requisite decrease in cost. At present the photovoltaics market consists of remote power, charging units, communication, cathodic protection, irrigation and consumer products. By 1990 or so there should be appreciable applications in rural areas of the Third World and the replacement of diesel power sources. During the first decade of the next century, large-scale applications in utilities, hospitals and factories may be expected in many developed countries including the U.S.A.

While much of the currently used material is Czochralski-grown crystalline silicon, by 1990 it may well be that the ribbon techniques will have achieved technological maturity and that thin film techniques will have progressed to the point that amorphous hydrogenated silicon films (possibly in tandem cells) will have achieved the required efficiencies and stability.

According to present thinking the thin film technology of choice will involve silicon in a very substantial way. It is difficult to predict how the thin film material will be derived or prepared in cells. For example, the direct source may be metallurgical-grade silicon prepared with additives such as hydrogen, fluorine or other constituents. Amorphous, microcrystalline, polycrystalline or crystalline materials may be utilized. Tandem thin film cells, if they can be fabricated, will have clear-cut advantages.

The current enthusiasm for the amorphous hydrogenated silicon technology stands in contrast with that involving other thin film materials such as the II-VI compounds. There may be some overreaction here; research involving these compounds should be continued on an appropriate scale.

GaAs is viewed primarily as having significant potential for concentrator applications. If current expectations remain valid, concentrator cells utilizing GaAs or silicon will be fully developed by the year 2000. Since a technology establishes its basic direction early in its life, it appears likely that silicon will be as ubiquitous to photovoltaics as the internal combustion engine is to automobiles.

The development of the technology appropriate for utility applications in the U.S.A. confronts some unknowns. The problem of cost has already been mentioned, as has the fact that the criteria for utility applications are stringent. According to the Electric Power Research Institute, an electricity cost of 15 c/kWh in the southwest portion of the U.S.A. requires a 15% module efficiency, a module cost of \$100 m^{-2}, a \$50 m^{-2} balance-of-systems cost, an 11% systems efficiency and a 30 year module longevity. Since the time scale for the development of the technology is longer than customary, industry is showing an understandable reluctance to continue what many regard as a risky venture, particularly during a time when the energy crisis seems to be alleviated. It should be recalled, however, that the time required to change from wood to coal and subsequently to oil was of the order of 30 - 50 years for each change. (30 years represents a natural unit even today since this period corresponds to the typical life of an electric generation plant.) Continued tax incentives to industry, designed to yield acceptable break-even costs, are essential to the continued development of photovoltaic technology.

The current curtailment of federal research support also represents a problem. While the emphasis on advanced research and development at the expense of premature deployment and demonstration projects is entirely appropriate, the overall R&D support levels are too low to develop an optimal knowledge base permitting sound development. A responsible rationale for appropriations increases of perhaps 25% for this purpose could be developed using the information and reasonable projections of the National Photovoltaics Program Five Year Research Plan.

The following are some generic research issues (as opposed to specific topics) that require attention.

(1) *Search for an optimal thin film technology:* this activity is meant to include not only the search for novel materials but more particularly their form. The amorphous and crystalline states should be viewed as opposite extremes of a continuum which includes microcrystals and polycrystals of increasing grain size. Despite the current enthusiasm about strictly amorphous materials, it may be that certain forms of microcrystalline materials are preferable.

(2) *Use of very-large-scale integration and layered semiconductor structure experience in photovoltaics research:* in order to establish a standard for the best prototype cells, it would be useful to prepare such cells utilizing the best available semiconductor techniques rather than those which have commercial utility. This approach could lead to an identification of the factors on which solar cell performance depends most critically. Moreover, the developing GaAs metal-oxide-semiconductor field effect transistor technology and that concerned with layered semiconductor structures could be used to further the development of concentrator cells which will surely be highly sophisticated fabrications. (High efficiency tandem cells which utilize these approaches are currently under development in the U.S.)

(3) *Exploration of photoelectrochemical applications:* at present the photovoltaics community does not regard these applications to be in the mainstream. It may well be that in the long term this will be one of the promising applications of photovoltaics.

(4) *Continuation of fundamental studies of amorphous hydrogenated silicon:* more detailed structural information concerning amorphous hydrogenated silicon would be most useful and could be obtained by using sophisticated bulk diffraction and surface techniques. Knowledge of the electronic structure and transport properties would benefit from further investigations directed at exploration of the intrinsic reasons of such issues as the low hole mobility. Fundamental understanding of amorphous materials undergirds qualitative improvements and should be encouraged for a variety of reasons transcending photovoltaic development.

(5) *Continuation of crystal growth research, particularly ribbon silicon:* these studies should include the mathematical modelling of the highly nonlinear effects of temperature gradients at the liquid-solid interface.

(6) *Understanding of interfaces, which are important in all semiconductor technologies, including photovoltaics:* the exploration of the properties of semiconductor-semiconductor, semiconductor-metal and semiconductor-electrolyte interfaces requires a concerted effort on the part of experimentalists who have access to sophisticated state-of-the-art preparation and diagnostic techniques and theorists who are able, because of the available computer facilities and the necessary software, to perform detailed and reliable calculations of the associated electronic properties. On the whole it is remarkable that more than 35 years after the discovery of the transistor, the ohmic contact to a semiconductor, let alone the Schottky barrier and technical problems such as "band off-sets", are not yet fully understood.

Successful projects in any of these areas would benefit not only photovoltaics but also the fundamental understanding of sophisticated materials and technologies of continuously increasing importance to the national interest.

The need for defining a proper federal role responsibility should be emphasized. The U.S. Department of Energy and other agencies could help to develop mechanisms for international market growth which do not infringe on the private industrial sector but which, at the same time, maintains our economic and technological position with respect to Japan and other nations. Most needed are methods for making contacts involving U.S. industries and their counterparts in other countries. Rural electrification projects often require interactions with governments rather than with private industries. In return for technological help in the installation and maintenance of photovoltaics, the U.S. could gain experience with Third World energy problems, the deployment of solar cells and market development. The opportunities are considerable. An installation of approximately 2 kW_p would provide outdoor lighting, television, refrigeration and emergency radio communications for a village having approximately 500 people and 100 homes. There are over a million such villages world wide. At an installation cost of $\$10/W_p$ this represents a $20 billion worldwide business before saturation. This is a minimal number. This intermediate goal, achievable with a 10 year period, is likely to result in a technology acceptable for U.S. utility applications.

Acknowledgments

The development of the viewpoint presented in this report has benefitted from the present author's participation in the following groups: American Physical Society Study on Solar Photovoltaic Conversion (1977 - 1979), U.S. Department of Energy Solar Photovoltaic Energy Advisory Committee (1980 - 1981), Solar Energy Research Institute Survey on Critical Photovoltaics Advanced Research and Development Identification (1982), White House Office of Science and Technology Policy Senior Scientific Panel on Indo-U.S. Scientific and Technological Cooperation (1982 - 1983), Electric Power Research Institute Photovoltaics Power Systems Evaluation Workshop (1982), DOE Study: "Photovoltaic Cell Research Priorities" (1983), Consultant to Exxon Research and Engineering Co. and Exxon Solar Power Co. (1979 - 1984).

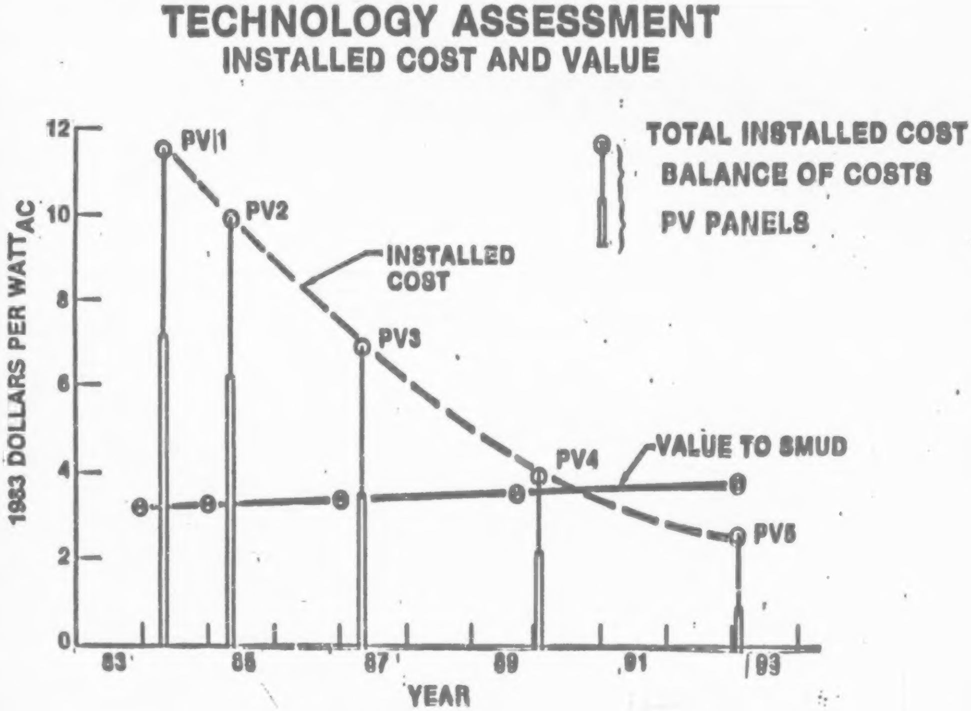
Mr. Fuqua. Thank you very much.

Mr. Anderson.

STATEMENT OF MARK W. ANDERSON, PHOTOVOLTAIC PROJECT MANAGER, SACRAMENTO MUNICIPAL UTILITY DISTRICT, SACRAMENTO, CA

Mr. Anderson. Mr. Chairman and members of the committee, I'm Mark Anderson, project manager for the Sacramento Municipal Utility District's photovoltaic project. On behalf of the District I'd like to thank you for the invitation to appear here today and give you a brief update on the project. I have a short viewgraph presentation, if I could get somebody to step to the projector or if there is a mike over there, I'd be happy to do it. I don't think my voice will carry very far today, I'm afraid.

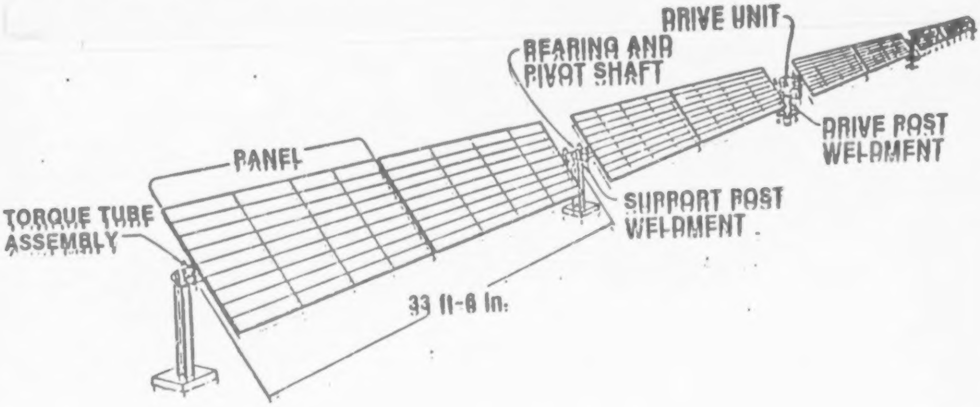
Mr. Fuqua. Dr. Watson will operate the viewgraph. I don't know whether Dr. Watson was trained in that or not, but maybe he can get a quick course in it.



Slide 1

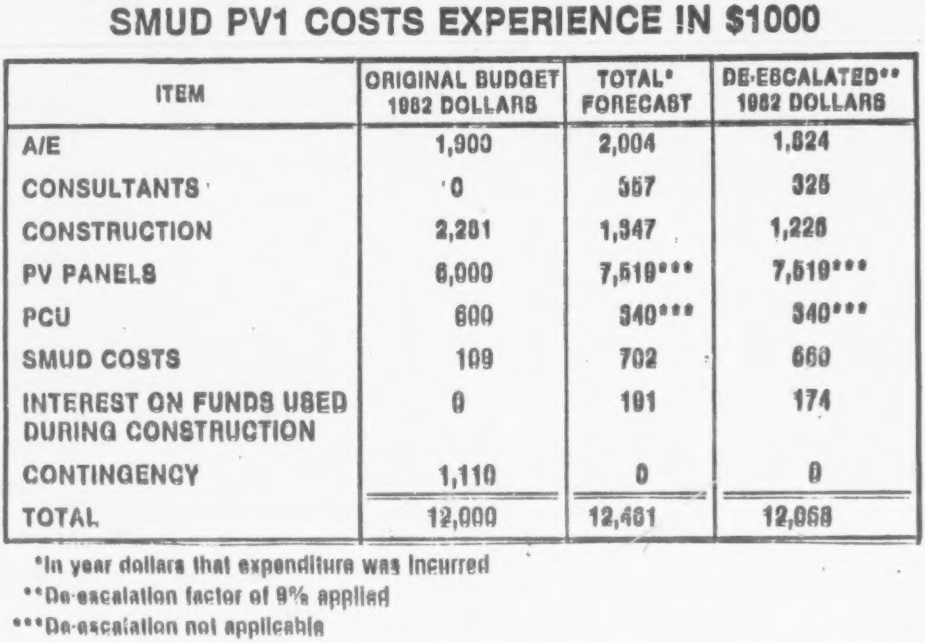
Mr. Anderson. This first slide is essentially the technology assessment we started with in 1980, at the beginning of the project. It shows our projections of where, at the time, we thought that the cost of each phase of the project was headed. The lower line you see is the value to SMUD line, roughly what we calculated, at that time to be the value of a system like this with the generating characteristics of a photovoltaic plant to our utility. On each line, showing each phase of the project, if you look at PV-1, for example, the double line shows the projected cost of the PV panels and the single line above that shows the total—the balance of system cost.

Next slide please. And this shows the type of structure we're using. It's a single access tracking structure. It had never been utilized before. Essentially when we started out the project we determined that our priority, as a utility, was to come up with a much more durable and reliable type of system than had ever been built before and I think we've achieved that. We've built a relatively simple system, but it's an extremely durable one with a design life of a minimum of 30 years, which I don't think had ever been achieved before in this technology and we've got it at a lower cost than I think has ever been achieved.


DRIVE UNIT
BEARING AND PIVOT SHAFT
DRIVE POST WELDMENT
PANEL
SUPPORT POST WELDMENT
TORQUE TUBE ASSEMBLY
33 ft-6 in.

SLIDE 2

Next slide please. This shows our cost experience. If you look at the bottom line our projected budget was $12 million, of which $3.2 million was supplied by SMUD and $6.8 million by the Federal Government and $2 million by the State of California. We actually spent or actually forecast to spend, construction is complete, we're in operation now, there's just some minor amounts left to be spent on reporting requirements. We spent $12,461,000, when that's deescalated back to our original budget year we come in about $50,000, $60,000 over budget roughly. Approximately a 5-percent overrun.



SMUD PV1 COSTS EXPERIENCE IN $1000

ITEM	ORIGINAL BUDGET 1982 DOLLARS	TOTAL* FORECAST	DE-ESCALATED** 1982 DOLLARS
A/E	1,900	2,004	1,824
CONSULTANTS	0	357	325
CONSTRUCTION	2,281	1,347	1,226
PV PANELS	6,000	7,519***	7,519***
PCU	600	340***	340***
SMUD COSTS	109	702	660
INTEREST ON FUNDS USED DURING CONSTRUCTION	0	191	174
CONTINGENCY	1,110	0	0
TOTAL	12,000	12,461	12,068

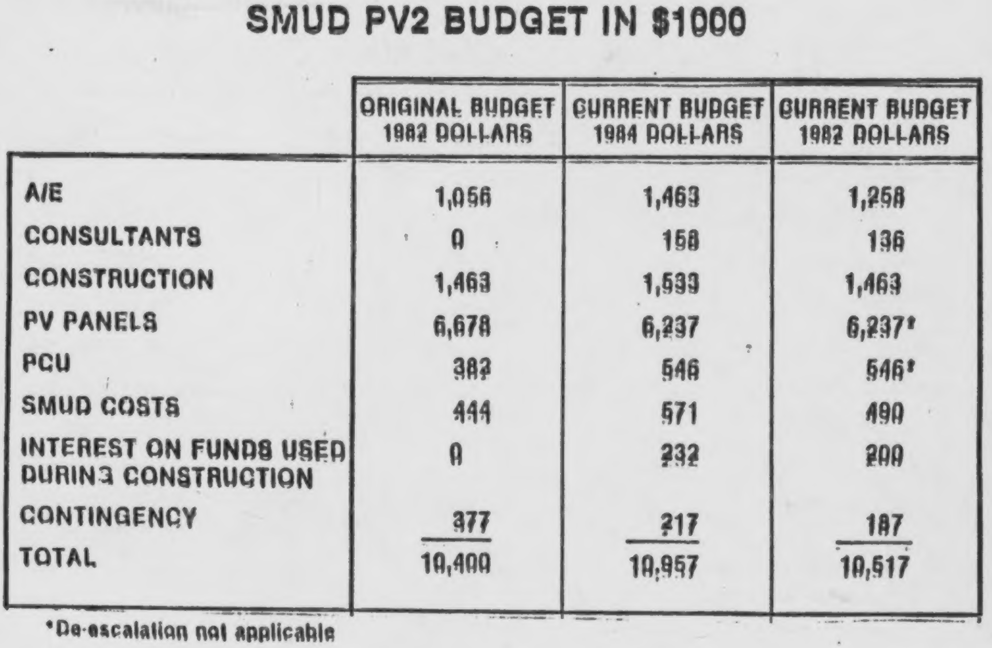
*In year dollars that expenditure was incurred

**De-escalation factor of 9% applied

***De-escalation not applicable

SLIDE 3

Next slide please. The second phase, which is also a 1-megawatt project, as was phase 1, had a projected budget of $10.4 million with $6.8, again coming from the Federal Government and $3.4 million from SMUD. SMUD, by the way, is responsible for all the cost overruns and for all operating and maintenance costs on the plant. We project to spend nearly $11 million and again when that's deescalated to our original budget that's a—shows a small overrun of $10.5 million.



SMUD PV2 BUDGET IN $1000

	ORIGINAL BUDGET 1982 DOLLARS	CURRENT BUDGET 1984 DOLLARS	CURRENT BUDGET 1982 DOLLARS
A/E	1,056	1,463	1,258
CONSULTANTS	0	158	136
CONSTRUCTION	1,463	1,533	1,463
PV PANELS	6,678	6,237	6,237*
PCU	382	546	546*
SMUD COSTS	444	571	490
INTEREST ON FUNDS USED DURING CONSTRUCTION	0	232	200
CONTINGENCY	377	217	187
TOTAL	10,400	10,957	10,517

*De-escalation not applicable

SLIDE 4

Next slide please. And we're now in the design phase of our third, 5-megawatt phase, which we call PV-3 and you can see our projected budget there of $38.9 million, of which we've allotted $24 million for the PV panels themselves and this is becoming a critical factor in the entire project. We saw panel prices of $5.60 per watt in phase 1. Approximately $5 per watt in phase 2, but really no progress in reducing panel costs, because the only—the reason for the decrease in price between phase 1 and 2 was simply we removed structure, and therefore, value from that particular contract, so effectively the price of the photovoltaic panels themselves never came down. We have set a budgetary limit of $4 per watt as the upper limit we will pay for panels on phase 3 and just recently bid those panels, bids were opened on February 21, with some rather disappointing results. We have since reissued the bid request with a deadline of March 21, have verified to the bidders that, I guess, strengthened the language behind our commitment to $4 a watt as a maximum price we will pay and also have extended out delivery schedule by some 10 months to allow the vendors some relief as they attempt to give us the price we're asking for.

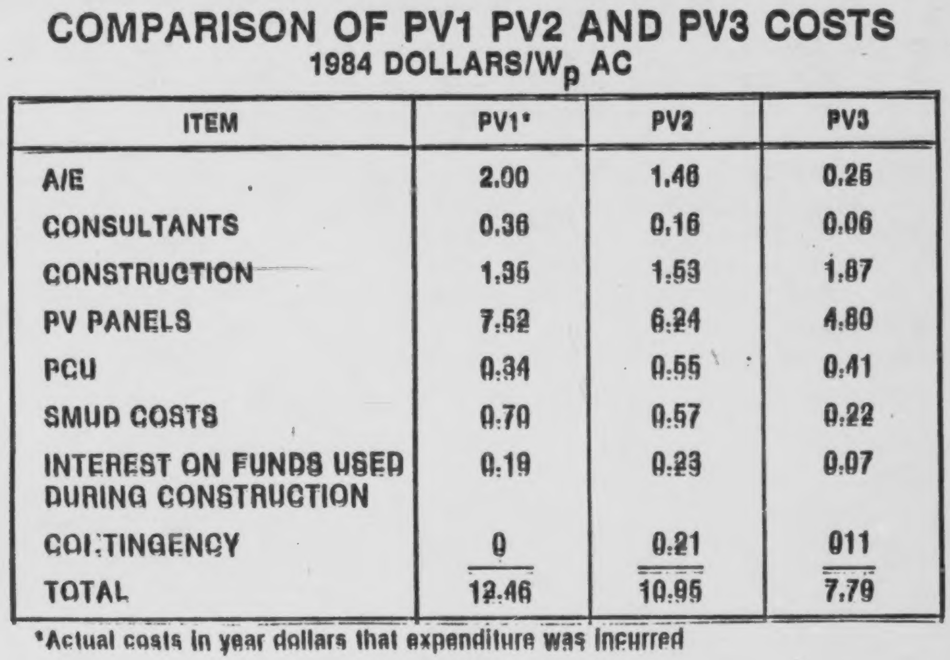
SMUD PV3 BUDGET

1984 DOLLARS

ITEM	COST FORECAST $1000
A/E	1,278
CONSULTANTS	295
CONSTRUCTION	9,340
PV PANELS	24,000
PCU	2,035
SMUD COSTS	1,100
INTEREST ON FUNDS USED DURING CONSTRUCTION	361
CONTINGENCY	560
TOTAL	38,959

SLIDE 5

Next slide please. Now this just quickly shows you a comparison of the costs on all three phases. We're tracking very close to that original slide that I showed you. Slightly running between 1 to 5 percent over budget on each of the first two phases and projecting actually a slight underrun at this point on phase 3.



COMPARISON OF PV1 PV2 AND PV3 COSTS

1984 DOLLARS/W_p AC

ITEM	PV1*	PV2	PV3
A/E	2.00	1.46	0.25
CONSULTANTS	0.36	0.16	0.06
CONSTRUCTION	1.35	1.53	1.87
PV PANELS	7.52	6.24	4.80
PCU	0.34	0.55	0.41
SMUD COSTS	0.70	0.57	0.22
INTEREST ON FUNDS USED DURING CONSTRUCTION	0.19	0.23	0.07
CONTINGENCY	0	0.21	011
TOTAL	12.46	10.95	7.79

*Actual costs in year dollars that expenditure was incurred

SLIDE 6

Next slide please. The—this shows the—summarizes the design selection process we went through on phase 1 and phase 3, again to choose the single access tracking technology that we're using. What we did was take a representative design for each of the four technologies you see there, a fixed flat panel system, one access tracking, a two-access tracking flat panel and a concentrating system. We estimated the cost of building each one, then estimated its worth by looking at the value of the capacity and energy that plant would generate over a 30-year life to come up with the worth column and then the net cost to the project.

DESIGN SELECTION SUMMARY

MM $1987

DESIGN	COST	WORTH	NET COST
FIXED FLAT PANEL	37.5	13.6	23.9
ONE AXIS TRACKING FLAT PANEL	38.4	15.3	23.1
TWO AXIS TRACKING FLAT PANEL	42.7	16.6	26.1
CONCENTRATOR	42.8	16.0	26.8

CONCLUSION: ONE AXIS TRACKING FLAT PANEL
RESULTS IN LOWEST NET COST

SLIDE 7

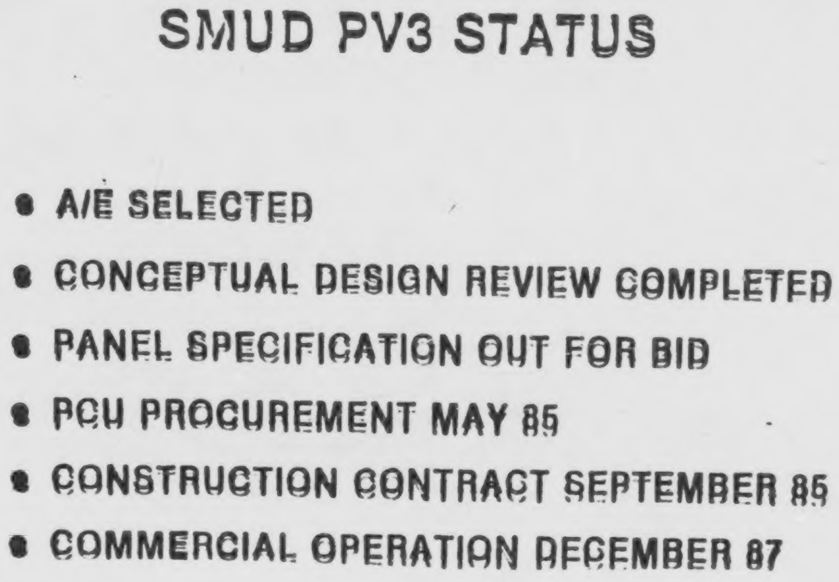
Next slide please. The status of the second phase, we've placed all our major procurement contracts, site construction is underway and going very well. We are nearly 75 percent complete. It should be finished by the end of April. Panel delivery will start in April. The power conditioning unit or the invertor, which inverts the direct current energy to an alternating current is —has slipped a little bit, it should be here near the end of May and initial operation is expected in December of 1985, that late only because it will take that long to receive all the panels that we have coming from three different vendors.

SMUD PV2 STATUS

- ALL MAJOR PROCUREMENT CONTRACTS IN PLACE
- SITE CONSTRUCTION UNDERWAY
    - SITE PREPARATION COMPLETE
    - FOUNDATIONS INSTALLATION COMPLETE
    - UNDERGROUND ELECTRICAL COMPLETE
    - SUPPORT POST INSTALLATION UNDERWAY
- PANEL DELIVERY EXPECTED TO START APRIL 85
- PCU DELIVERY EXPECTED APRIL 85
- INITIAL OPERATION EXPECTED DECEMBER 85

SLIDE 8

Next slide please. And the status of PV-3, we have our architect engineer onboard, a new one this time, Stone & Webster Engineers, the conceptual design review, which you just saw the results of, has been completed. Panel specification is out for a rebid at this time. The power conditioning unit will be procured in May. Construction contract will be bid in September 1985 and commercial operation is expected in December 1987. I think you can hold—yes, that should do it.



SMUD PV3 STATUS

- A/E SELECTED
- CONCEPTUAL DESIGN REVIEW COMPLETED
- PANEL SPECIFICATION OUT FOR BID
- PCU PROCUREMENT MAY 85
- CONSTRUCTION CONTRACT SEPTEMBER 85
- COMMERCIAL OPERATION DECEMBER 87

Slide 9

That concludes my presentation. I'll be happy to answer any questions you may have.

[The prepared statement of Mr. Anderson follows:]

TESTIMONY OF MARK W. ANDERSON, P.E.

PHOTOVOLTAIC PROJECT MANAGER
SACRAMENTO MUNICIPAL UTILITY DISTRICT

BEFORE
THE
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

MARCH 5, 1985

SMUD PHOTOVOLTAIC PROJECT

Background

The SMUD Photovoltaic Project (SMUDPV) is a joint project in which the Sacramento Municipal Utility District (SMUD) and the U.S. Department of Energy (DOE) have joined forces to design and construct, in phases of varying size, a 100-megawatt photovoltaic generating facility. The project strategy calls for SMUD to cost-share that portion of each phase which represents the cost SMUD would pay for a commercially viable generating source with similar generating characteristics. The DOE cost share for each phase is the difference between the estimated cost and SMUD's share. SMUD manages the design and construction and becomes the owner and operator of each phase as it is completed. SMUD is responsible for cost overruns during construction, and for the costs of operation and maintenance.

The project schedule and budget are shown below, and in Attachment 1. Attachment 2 is a graphical comparison of SMUD PV-1 costs to costs seen on other DOE-funded PV projects.

Phase	Budget ($Million)	On-Line Date	Size (Megawatts
PV-1	6.8 DOE 3.2 SMUD 2.0 State of California 12.0	8-1-84	1
PV-2	6.8 DOE 3.6 SMUD 10.4	12-1-85	1
PV-3	20.0 DOE* 20.0 SMUD 40.0	12-1-87	5
PV-4	80.0 SMUD	7-1-90	20
PV-5	226.0 SMUD	7-1-93	73
Total	368.4		100

*$11.5 Million dollars has been appropriated ($1.5 million in FY84 and $9.5 million in FY85). An additional $9.0 million in FY86 Federal funding is required to continue the project.

Project Objectives

SMUD

SMUD's objective in the overall project is to design, procure, and construct a 100-MW photovoltaic (PV) powerplant at its Rancho Seco Nuclear Generating Station site near Sacramento, California.

In the first phase, SMUD designed a PV powerplant consistent with prudent utility practices even though existing PV equipment was not specifically configured for the central station system design and construction.

In the second phase, SMUD's objective was to standardize the PV hardware interface so that PV equipment, suitable for large-scale central station applications, could be purchased for more than one supplier. By defining standard interfaces, SMUD expanded its sources for PV equipment by qualifying additional vendors. SMUD anticipated that lower cost in future phases could be obtained by establishing lasting design criteria.

SMUD's objective, in this third phase, is to realize further PV system price and technology goals to make central station PV power competitive with other generation sources. The current principal goals are to:

- Build a $5MW_{AC}$ photovoltaic power plant for $40 million
- Design the 5MW system so that it may be used as a building block for future larger systems.
- Utilize hardware which meets utility requirements for performance and reliability
- Continue the development of utility experience with large, grid-connected PV systems.
- Support the development of advanced power conditioning unit design.
- Provide investment motivation for the PV industry by establishing a long-term market opportunity at price levels which support industry development.

Department of Energy

The DOE objective in this third phase is to advance PV technologies and balance of system designs to the extent feasible within funding limitations. The procurement of PV hardware from multiple vendors will also work to broaden the participation of the PV industry in the commercialization experience provided by this project.

Current Status

PV-1 was completed July 1, 1984, went into commercial service on August 1, 1984, and is currently generating power for SMUD customers.

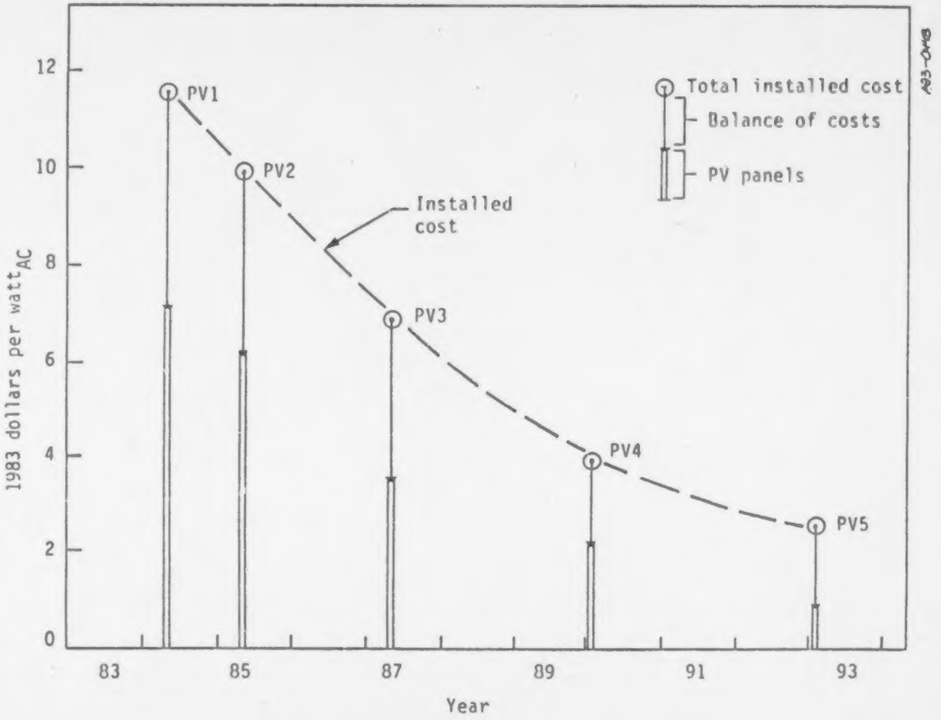
PV-2 is completely designed and all major purchase and construction contracts have been awarded. This phase is currently on schedule and within budget.

PV-3 Design work began in October, 1984, with the Conceptual Design Selection Study. Based on the results of this evaluation of alternative PV system designs, it was decided that the single-axis, tracking concept used in PV-1 and PV-2 will be continued in PV-3. Bid Requests for 6MW (DC) of PV panels were released in January, 1985, and bids were received on February 21, 1985. The bids received exceeded the project's budgetary limit for panels by a approximately $7 million. Consequently, SMUD has issued an addendum to the bid request which increased the time allowed for delivery of the PV panels, and extends the bidding period out to March 21, 1985.

ATTACHMENT 1

TECHNOLOGY ASSESSMENT

INSTALLED COST AND VALUE



ATTACHMENT 2

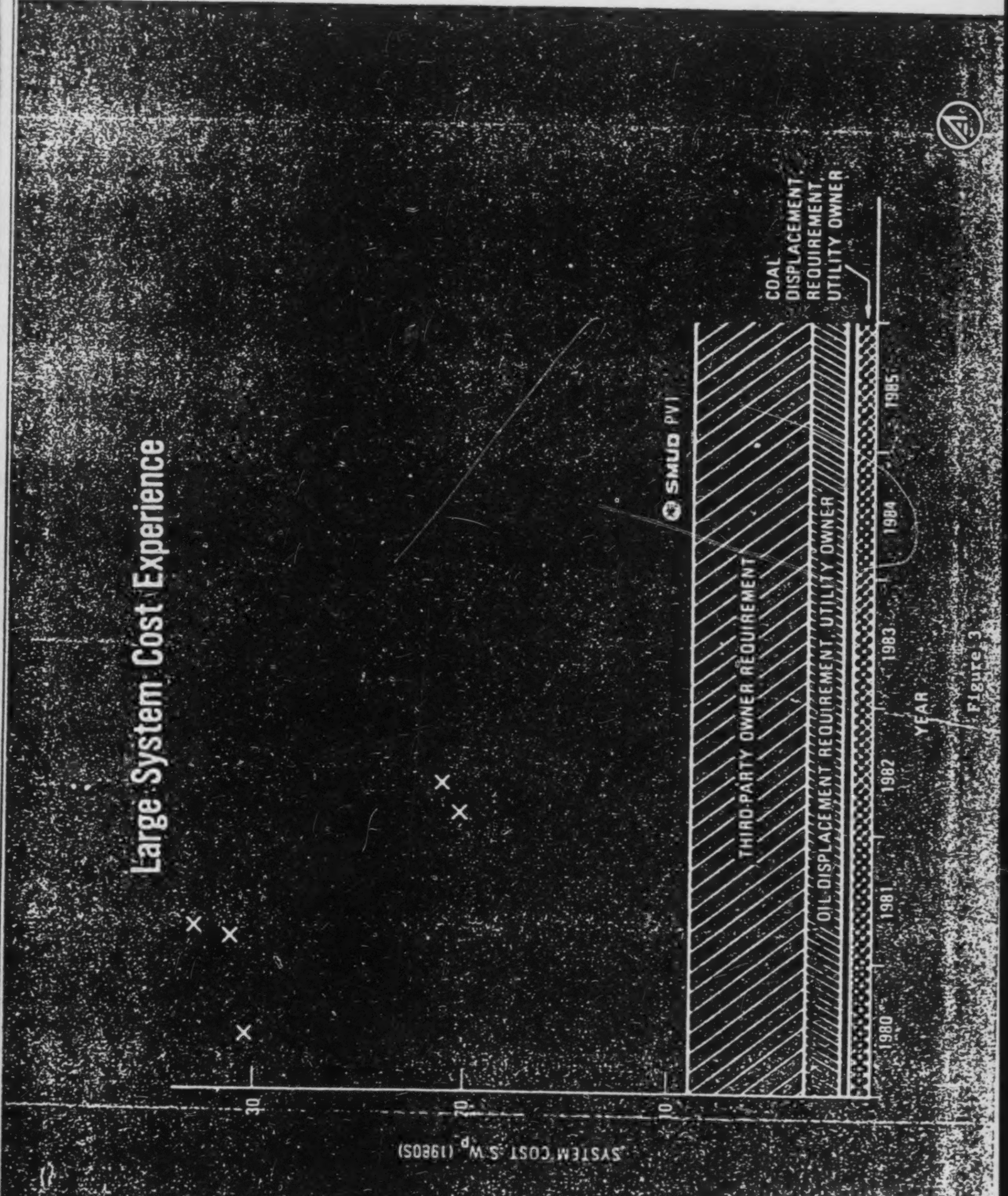


Figure 3

Mr. FUQUA. Thank you, very much.

Dr. Klass.

STATEMENT OF DR. DONALD KLASS, PRESIDENT, BIOMASS ENERGY RESEARCH ASSOCIATION, WASHINGTON, DC

Dr. KLASS. Mr. Chairman and members of the subcommittee, I am pleased to have the opportunity to address the Energy Development and Application Subcommittee of the House Committee on Science and Technology. My name is Dr. Donald Klass and I am speaking on behalf of the Biomass Energy Research Association.

BERA is a nonprofit association founded by biomass researchers to promote education and research related to the development of biomass energy systems and to inform and educate American industry and serve as a source of data and information concerning biomass policies and programs. Since its founding in 1982, BERA has been privileged to share our member's ideas and concerns with Congress and to speak in support of a continued Federal commitment to the U.S. Department of Energy Biofuels Energy and Development Program.

The biofuels program now consists of municipal solid waste, alcohol fuels and biomass R&D programs. I would like to take a moment to reemphasize some fundamental, but key, points that make biomass energy unique among the renewable energy technologies. First, biomass energy can readily provide liquid, gaseous and solid fuels, as well as electricity by application of suitable conversion processes. Biomass could contribute up to 10 to 17 quads of energy to the Nation's primary energy supply with vigorous R&D support. Many biomass energy applications are economically viable without Federal subsidies and tax program. Examples are certain wood fuel combustion systems for steam and processed heat production and landfill methane recovery systems. Biomass does not require the development of storage technologies to become viable, as the energy is stored within the fuel in the same manner as traditional fuels like coal and oil.

We appreciate the difficult challenge facing Congress and the administration as efforts are made to strike a balance between prudent national energy development policy and fiscal restraint. The option of funding every technology program is no longer financially viable. Each must be scrutinized in terms of its potential contribution to national energy security and its cost effectiveness at achieving this goal. It is our conviction that biomass technology is an important national energy resource, which passes the litmus test for Federal investment. In a time of difficult fiscal decisions we believe money invested in biomass energy is well spent. Furthermore, the biomass energy industry is disaggregated and market segmented and has neither the money nor personnel to conduct the needed basic R&D activities; therefore, the Federal Government's leadership is essential now to insure that biofuels technologies and the interest structure necessary to utilize these technologies are available when they're needed.

The BERA budget proposals that I am submitting today are a product of a wide solicitation of ideas from our members. A review of the fiscal year 1985 DOE Biomass Energy Technology Program accomplishments and consideration of those programs, we believe, will deliver the best output for Federal dollar invested. The proposed BERA budget reflects three major themes and concerns that we have about the fiscal 1986 Department of Energy Biofuels Energy Program.

First, in fiscal 1985 two previously separate programs, municipal solid waste and alcohol fuels, were fully integrated into the biomass program. We support the full integration of bioconversion technologies into the Biofuels Program, however, this integration was done without an appreciable increase in total program dollar support of the biomass budget. Thus, the fiscal 1985 program operated with a net decrease in program funding activities. Our fiscal 1986 proposed budget rectified this by recommending that additional moneys be given to the most cost effective biofuels activities.

Second, BERA continues to believe in the near term potential of medium-Btu gasification. As we have stated in previous years, we believe that medium-Btu gasification has excellent near term potential. We appreciate the support that Congress gave us last year in initiating a program for the scale-up of promising candidate processes that produce medium-Btu gas from a variety of feed stock. Therefore, BERA requests an additional $5 million be specifically appropriated to provide for a continuing Government contribution to this cost shared scale-up program. It is essential that this cost shared scale-up work be funded and performed as a separate activity from the basic thermal chemical research and development program to preclude the possibility of premature termination of important research projects due to a shortage of funds. We further recommend that the first process elected for scale up be chosen by competitive procurement and that other promising technologies be chosen for scale up in a continuing program.

BERA also believes that there is a need to promote new and innovative research in the Biofuels Program. We encourage the Biofuels Program managers to be responsive to new ideas and approaches to meet their program goals. Many of the technologies being funded have reached a stage of maturity that make them ready for scale up work. It is important to continue funding these existing activities, however, we propose that a part of each program element be devoted to the search for new and fundamental research ideas, in this way the biomass program will infuse the technology pipeline with fresh and potentially high payoff activities. Examples are research to develop plant hybrids, which directly produce fuels, advanced fermentation technology and new catalytic processes for biomass conversion.

Mr. Chairman, I've attached detailed budgetary recommendations for your consideration, to our written testimony. I'd be pleased to answer any questions you may have now, or later in writing and I greatly appreciate this opportunity to speak before you today. Thank you very much.

[The prepared statement of Dr. Klass follows:]

TESTIMONY
BY
THE BIOMASS ENERGY RESEARCH ASSOCIATION
BEFORE THE
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY

MARCH 5, 1985

Good morning, I am pleased to have the opportunity to address the Energy Development and Applications Subcommittee of the House Committee on Science and Technology. My name is Dr. Donald Klass and I am speaking on behalf of the Biomass Energy Research Association (BERA).

Since its founding in 1982, BERA has been priviledged to share our member's ideas and concerns with Congress and to speak for a continued federal commitment to biofuels energy research and development.

I would like to take a moment to re-emphasis some fundamental but key points that make biomass energy unique among the renewable energy technologies.

- First, biomass energy can readily provide liquid, gaseous and solid fuels as well as electricity.

- biomass could contribute up to 10-17 Quads of energy to the Nation's energy supply with vigorous R & D support.

-Biomass energy is economically viable without federal subsidies and tax programs.

-Biomass does not require the development of storage technologies to become viable, as the energy is stored in the fuel in the same manner as traditional fuels like coal and oil.

We appreciate the difficult challenge facing Congress and the Administration as efforts are made to strike a balance between a prudent national energy development policy and fiscal restraint. The option of funding every technology program is no longer financially viable. Each must be scrutinized in terms of potential contribution to the national energy security and cost-effectiveness at achieving this goal.

It is our conviction that biomass technologies are important national energy resources which pass the litmus test for federal investment and in a time of difficult fiscal decisions we believe money invested in biomass energy is well spent. Furthermore, the biomass industry is disaggregated and market segmented and has neither the money or personnel support for basic R & D activities. Therefore, the federal government leadership is essential now to insuring that the biofuels technologies and infrastructure are available when needed.

The BERA budget proposals that I am submitting today are a product of a wide solicitation of ideas from our members, a review of the Fiscal Year 1985 Biomass Energy Technology program accomplishments, and consideration of those programs we believe will deliver the best output per federal dollar invested.

The proposed BERA budget reflects three major themes and concerns that we have about the FY 1986 Biofuels Energy Program.

First, in FY 1985 two previously separate programs - municipal solid waste and alcohol fuels were fully integrated into the biofuels program. We support the full integration of biotechnologies into the biofuels program, however, this integration was done without an appreciable increase in total program dollars. Thus, the FY 1985 program operated with a net decrease in program funding for all activities. Our FY 1986 proposed budget rectifies this by recommending additional monies be given to the most cost-effective biofuels activities.

Secondly, BERA continues to believe in the near term potential of medium- Btu gasification. As we have stated in previous years, we believe that medium-Btu gasification has excellent near-term potential. We appreciate the support that Congress gave last year in initiating a program for the scale-up of promising candidate processes that produce medium-Btu gas from a variety of feedstocks. Therefore, BERA requests an additional $5.0 million be specifically appropriated to provide for a continuing government contribution to this cost-shared, scale-up program. It is essential that this cost-shared scale-up work be funded and performed as a separate activity from the basic thermochemical R & D program to preclude the possibility of premature termination of important research projects due to a shortage of funds. We further recommend that the first process selected for scale-up be chosen by competitive procurement, and that other promising technologies be chosen for scale-up in a continuing program.

BERA also believes that there is a need to promote new and innovative research in the biofuels program. We encourage the biofuels program managers to continue to be responsive to new ideas and approaches to meet their program goals. Many of the technologies being funded have reached a stage of maturity that make them ready for bench or larger scale-up work. It is important to continue funding these existing activities. However, we propose that a part of each program element be devoted to the search for new and fundamental research ideas. In this way, the biomass program will infuse the technology pipeline with fresh and potentially high-payoff actvities. Examples are research to develop plant hybrids which directly produce fuels, advance fermentation technology, and new catalytic processes for biomass conversion.

A more detailed description of our budget proposals follows.

I would be pleased to answer any questions you have now, or later in writing and I greatly appreciate this opportunity to speak before you today.

FY 1986 BIOMASS ENERGY TECHNOLOGY PROGRAM PROPOSED BUDGET

A. BIOMASS FEEDSTOCK PRODUCTION RESEARCH ($8,300,000)

In the area of production, much of the work being conducted can be characterized as innovative, particularly in the areas of genetics and biochemistry. We encourage the Program Managers of the three production programs to continue to be responsive to new and innovative ideas and approaches to meet their program goals, especially those that could result in significant improvements in yields or quality of feedstock.

1. Short Rotation Woody Crops.................$4,700,000

The Short Rotation Woody Crops program continues to yield promising data about the potential of growing woody crops on a short rotation schedule. Research is still needed to examine successive resprouting of trees, and the number of harvests possible before replanting is necessary. Basic research to remains the key to a successful SRWC program. Genetics and tissue culture research resulting in the creation of superior genotypes with better growth characteristics such as yield, pest resistance, and water range and physiological research need continued support.

2. Aquatic Species..........................$1,500,000

Aquatic species research should focus on screening for promising microalgae species and further improving their suitability for energy production by manipulating their genetics and physiology. Small-scale field experiments continue to be needed to provide data on growing sustained high yields of algae and on their behavior as operating parameters are varied.

3. Herbaceous Species......................$2,100,000

Before growing energy crops can become a viable economic option for farmers, research needs to be conducted to select and breed highly productive herbaceous crops with species being produced for various geographical regions of the U.S. This includes basic genetic and physiological research on plants from throughout the U.S. as well as small-scale field testing. Research should also continue on the use of oil seed crops for the production of liquid fuel substitutes.

B. BIOMASS CONVERSION TO FUELS ($16,700,000)

The biochemical and thermochemical programs should pursue innovative research ideas that can lead to new breakthroughs in methods for converting biomass resources to energy. For example, in the biochemical area, this fundamental research might include work in new genetic techniques to perfect the development of plant hybrids for use as liquid fuels and in thermochemical conversion, many basic research issues remain in the area direct liquifaction and ultrafast pyrolysis of biomass.

1. Biochemical Conversion..................$7,300,000

Biochemical conversion processes have the potential for the efficient conversion of biomass into relatively high value liquid fuels. The biochemical conversion program should address the utilization of all components of abundant lignocellulosic feedstocks. Furthermore, the program should examine bioconversion routes to other potential liquid fuels such as higher alcohols, other oxygenated liquid fuels and aromatic octane enhancers.

Many impediments remain to the effectively utilize lignocellulosic feedstocks (wood, crop residues) because of their resistance to bioconversion. Cost-effective pretreatments should be developed to increase their biodegradibility. Novel bioconversions such as immobolized enzymatic cellulose hydrolysis and the fermentation of pentoses to ethanol must be improved to afford more rapid fermentation rates, greater yields and fewer by-products. The emerging tools of genetic engineering offer many potential methods of effecting the improvements needed. Once the fundamental elements of a bioconversion process are identified, many steps still remain before a practical system can be realized. Bio-reactor designs appropriate for a given bioconversion must first be identified and optimized at the bench and then intermediate scales.

Process elements must be integrated into a complete system that addresses uncertainties associated with the matching of process components, the purification and/or handling of products and waste streams and the efficient management of energy. Cost goals should be developed to guide and assess ongoing research.

Anaerobic digestion of lignocellulosics to produce methane is also impeded by the resistant character of these feedstocks. Advance digestion methods, pre-and post-treatments, and genetic engineering should again prove valuable in developing organisms exhibiting enhanced digestion rates. Different reactor configurations may offer further improvements in throughput rates. Only through a dedicated long term effort can our most abundant biomass resources be effectively exploited for transportation fuels.

2.Thermochemical Conversion...................$9,400,000

Research has expanded our knowledge of the gasification characteristics of lignins and highly-oxygenated cellulosics in biomass, and helped to solve the engineering problems encountered in developing improved reactor configurations and process designs. Much of the U.S. work is aimed at the development of fluid-bed processes because of their inherent advantages (e.g. at Battelle-Columbus Laboratories, IGT, University of Missouri- Rolla, Pacific Northwest Laboratory, Texas Tech University, Kansas State University, EEE Corp.), although other process configurations, such as steam gasification in a rotary kiln (Wright-Malta Corp) and in down-draft, fixed-bed gasifiers(SERI) also under development. Unlike fixed-bed gasifiers, fluid-bed gasifiers are capable of accepting a broad range of feedstocks including those high in moisture and ash content, and those that are highly variable in physical shape.

The FY1986 R & D program should continue to conduct research to improve gasifier designs, catalyst systems, and process conditions for both low-and medium-Btu gasification. The advanced processes that offer superior conversion effeciencies, selectivities, and yields should be emphasized in this work. In our testimony last year, BERA noted that recent efforts to commercialize low-Btu gasifiers have encountered several technological limitations. Recently, the DOE-sponsored workshop on low-Btu gasification, which included both the R & D community and industry, identified these limitations more cleanly. This workshop addressed the state-of-the-art and research needs to stimulate commercial use. Research and development funding is necessary to fill the technology voids identified at the workshop.

C. MEDIUM BTU GASIFICATION SCALE-UP (\$5,000,000)

BERA continues to believe in the near term potential of medium-Btu gasification. Therefore, BERA requests an additional \$5.0 million be specifically appropriated to provide for a continuing government contribution to this cost-shared, scale-up program. It is essential that this work be performed as a separate activity from the basic thermochemical R & D program to preclude the possibility of premature termination of important research projects. We further recommend that the first process selected for scale-up be chosen by competitive procurement, and that other promising technologies be chosen for scale-up in a continuing program.

D. REGIONAL BIOMASS ENERGY ACTIVITIES ($4,000,000)

BERA recommends that funding for the regional program be maintained at the FY 1985 level for the existing regional programs (Northeast,Lake States, Southeast and Pacific Northwest). The regional program is important in promoting the implementation of novel DOE-developed bio-energy technologies for specific applications of importance to energy consumers in the regions supported under this program. By emphasizing industry and state cost-sharing in their activities, the regional programs help extend the utility of Federal funding while ensuring the relevance of Federally-supported R&D.

BERA also offers some specific guidance regarding the activities within the funded regions. Regional efforts should enhance the utilization of biomass energy by helping to develop an infrastructure for supplying biomass conversion equipment and technical know-how. Recommended activities include the characterization of available rseources, development of channels for supply, and emission testing. The compliation of case studies of regional bio-energy projects would help promote public awareness of bio-energy potentials and would identify expertise important to the initiation of new projects. Finally, regional programs should assist with the refinement of technologies such as low-Btu gasification that no longer receive Federal R&D support because of their perceived advanced state of development.

CAPITAL EQUIPMENT	$ 800,000
TOTAL BERA FY 86 BUDGET RECOMMENDATIONS	$34,800,000

Mr. Fuqua. Thank you.
Dr. Berger.

STATEMENT OF DR. MICHAEL E. BERGER, DEPUTY ASSOCIATE DIRECTOR, ALTERNATIVE ENERGY SOURCES, LOS ALAMOS NATIONAL LABORATORY, LOS ALAMOS, NM

Dr. Berger. Thank you, Mr. Chairman, for the opportunity to report to you all again today. With your permission I think I'll skip over the introductory and background remarks and assume that you all are familiar with the technology since we've spoken about it before, and just report on what we've accomplished in the last year, since we talked to you last and what our future plans are.

As we reported to this committee last year, we've now drilled two holes at Fenton Hill, the depth of about—in northern New Mexico—to depths of about 14,000 feet, where the temperature in the rock is greater than 600 degrees Fahrenheit. And we have attempted to connect them by pressurizing one of the holes. In this fracturing experiment we pumped almost 6 million gallons of water at pressures of 7,000 pounds per square inch when one of the pipes broke. This permitted the water in the well, in the fracture system, to return to the surface and to shoot out at high pressure and temperatures above the boiling point. We had a man-made geyser that erupted for over 1 week and it was convincing proof that we had created a large well-connected fracture system.

However, the fractures did not connect the other well and the violent eruption seriously damaged the casing and the special hardware used to seal the opening between the casing and the pressure tubing. And our first major job this year was to repair the damage.

Just simply determining the location and nature of the damage in a very hot well at this depth of about 2 miles is an extremely difficult job and repairing it involves some risky operations. However, with the help of the best consultants and industrial experts that we could find, we succeeded and subsequently pressure tested the repaired well to about 5,000 pounds per square inch. This operation required about 10 weeks in the middle of one of the most severe winters in New Mexico history and cost approximately $1.3 million. However, it did salvage a well that cost $7.3 million in 1980 dollars. It was one of the most difficult well repair jobs ever attempted and completing it successfully was certainly our most spectacular accomplishment this last year.

During the fracturing operation the formation and extension of the fractures are accompanied by small sounds or acoustic emissions that can be detected by very sensitive instruments. In the Hot Dry Rock Geothermal Energy Program it's very important for us to know the location of the fractures we have produced. Determining these things through solid rock is a real challenge. We have, therefore, pioneered in mapping fractures by carefully determining locations where the sounds originate. It is a technique that has been found useful in other programs and by industry. Our maps of the locations show they are distributed throughout a volume of rock that is 3,000 feet long, 2,600 feet high and 500 feet thick. That's about 4 billion cubic feet of fractured rock. Unexpectedly this zone of broken rock passed to the north of the other well and did not intersect it. This is quite different from the fracturing behavior we had determined in our previous system and this discovery caused us to change plans for completing the connection. We are redrilling an existing well and turning it away from its old trajectory and drilling it into the fractured reservoir. Drilling out of an existing well in hard rock is quite difficult; however, we were able to drill out the side, along a new trajectory directed toward the fracture system. At this point we reached the maximum safe working distance of the rig and it was dismissed.

This operation took 6 weeks and cost $1.1 million. In spite of the difficulties encountered this high risk operation, like the well repair on the other hole, was completed on schedule.

Our intention is to continue the redrilled hole to intersect the fractures. Our plans for this drilling operation are being reviewed by two industrial organizations with broad geothermal experience and again, on schedule, we have contracted with a drilling company to do the drilling for us and a large drill rig is currently being assembled at the Fenton Hill site. Drilling operations should begin this weekend. We expect them to be completed in about 90 days at an estimated total cost of $2 million. Upon successful completion of redrilling we will run short-term flow tests through the connected underground system to obtain preliminary information on system behavior and operating conditions. This testing will bring up to the end of fiscal year 1985.

During fiscal year 1985 total funding for the Hot Dry Rock Geothermal Program was $14.1 million, of which $5 million has been provided by the Governments of West Germany and Japan through an International Energy Agency agreement with the U.S. Department of Energy. However, our 1985 funding has not been sufficient to cover some of the major procurements needed to create a surface system that we will need to verify that the reservoir is indeed what we think it is. This will have to be done in fiscal 1986, after which we will initiate a long-term flow test. The surface system will be expensive and our total funding requirement for fiscal 1986 is $13.5 million. Negotiations are currently in progress for extension of the International Energy agreement, under which West Germany and Japan each provide $2.5 million to help support the Hot Dry Rock Program. That agreement expires this year on September 30, and it is very important that it be renewed. If the agreement is renewed in its present form our funding requirement from the Department of Energy then will be $8.5 million.

Much of the technology so far developed for the Hot Dry Rock Program has been adopted by industry and we're very concerned about technology transfer. These include such things are improved drilling and well completion, high-temperature instruments, acoustic fracture—and acoustic mapping methods.

However, even more important, the U.S. program has brought worldwide attention to fact that hot dry rock exists at useful temperatures and accessible depths almost everywhere and that the technology to develop hot dry rock energy systems by hydraulic fracturing is approaching the point where it can be applied commercially.

Interest in such systems have been encouraged by several preliminary economic studies that have already been published and currently the Electric Power Research Institute is conducting its own independent study of the technology. Strong interest in hot dry rock has been shown by several organizations. We have been contacted by the California Energy Commission and the New York Energy Research and Development Authority, to name two. We have also had interest shown by the Utah—representatives at the Utah State Legislature. Of course the Germans and Japanese have shown interest in the technologies and a recent report in the technology press states that three hot dry rock projects are currently being undertaken in the Soviet Union. We have also been contacted by an industrial firm in Australia about the technology. However, the U.S. Hot Dry Rock Program is the broadest, most ambitious and most advanced in the world. We sincerely appreciate the support this committee has given the technology in the past and hope this support can be continued so that hot dry rock can soon be used to improve our energy security. Thank you.

[The prepared statement of Dr. Berger follows:]

TESTIMONY
FOR THE
HOT DRY ROCK GEOTHERMAL ENERGY PROGRAM

of

Michael E. Berger
Deputy Associate Director
Alternative Energy Sources
Los Alamos National Laboratory

to

United States House of Representatives
Committee on Science and Technology
Subcommittee on Energy Development and Applications

March 5, 1985

The Hot Dry Rock Geothermal Energy Program is funded by the U.S. Department of Energy and, under an International Energy Agency Agreement, by the governments of Japan and the Federal Republic of Germany.

Thank you for the opportunity to report to you again on the progress of the Hot Dry Rock Geothermal Energy Program.

The thermal energy in hot rock beneath the earth's surface is one of the largest and, in many places, the most accessible supply of energy that is available to man. The primary objective of the Hot Dry Rock Program is to develop a technology that the private sector will find practical and economical for producing useful energy from this essentially inexhaustible resource. We are well on the way toward accomplishing that objective, and believe that--in preparation for the time when the United States will need a large additional source of energy--the Federal expenditure in developing hot dry rock technology is a wise and prudent investment. The governments of the Federal Republic of Germany and Japan also support this technology through an International Energy Agency agreement with the United States Department of Energy.

As you may remember, the method that we originally developed for recovering heat from the earth's crust is to drill two holes and then to connect them through a set of cracks produced by pressurizing one of the holes. Water pumped down one hole is heated as it circulates through the cracks, and is brought to the surface through the other hole under sufficient pressure to keep it from boiling. Its useful heat is removed in heat exchangers, and the water is returned to recirculate and recover more heat. This is a closed-loop, recirculating system that has proved to be environmentally benign.

Several years ago we completed the world's first energy system of this type, at Fenton Hill in the mountains of northern New Mexico. We operated it for more than a year with no corrosion or scaling problems, acceptably low rate of water loss, and no detectable environmental effect. It brought heat to the surface at a temperature of about 280 degrees F, at a rate such that it could have heated several hundred houses--probably for many years. We did use part of the heat to generate electricity in a small experimental power plant, but the temperature and rate of heat production were not sufficient to support a commercial power plant. Therefore, we have since undertaken development of a larger, hotter system that is capable of doing that.

As we reported to this committee last year, we have now drilled two holes at Fenton Hill to depths around 14,000 feet, where the rock temperature is above 600 degrees F and have attempted to connect them by pressurizing one of the holes with water--an operation called "hydraulic fracturing." In our largest hydraulic-fracturing experiment, we had pumped almost six million gallons of water out into the rock at a pressure of about 7000 pounds per square inch when a threaded connection at the wellhead broke. This permitted the water in the well and the fracture system to return to the surface and shoot out through the broken connection--at high pressure, and temperatures far above the boiling point. Much of the water promptly turned to steam, and we had a man-made geyser that erupted continuously for over a week. It was convincing proof that we had created a large, well-connected fracture system, and that the water we had injected was effective in extracting a great deal of heat from the rock around it. This was encouraging with regard to the potential usefulness of the fractured rock volume as a large source of high-temperature heat. However, the fractures did not connect to the other well, and the violent eruption had seriously damaged the steel casing of the well, the pressure tubing through which we pumped in the water, and the special hardware used to seal the opening between the casing and the tubing. Our first major job this year was to repair the damage.

Simply determining the location and nature of the damage in a very hot well at a depth of about two miles is an extremely difficult job, and repairing it involves some very risky operations. However, with the help of the best consultants and industrial experts that we could find, we managed it--and pressure-tested the repaired well to about 5000 pounds per square inch. The entire operation required about ten weeks (in the middle of one of the worst winters in New Mexico history) and cost approximately $1.3 million. However, it salvaged a well that cost $7.3 million in 1980 dollars. It was one of the most difficult well-repair jobs ever attempted, and completing it successfully was certainly our most spectacular accomplishment during the past year.

During a hydraulic-fracturing operation the formation and extension of the fractures are accompanied by small cracking sounds--"acoustic emissions"--that can be detected by very sensitive instruments called geophones or seismometers. In the Hot Dry Rock Program, it is very important for us to know the location and size and shape of the hydraulic fractures that we produce. Determining these things through hundreds or thousands of feet of solid rock is a real challenge. We have therefore pioneered in mapping fractures by using geophones to map the locations at which the sounds originate--which is where fracturing is occurring. We are still improving both the instruments used to detect the signals and the computerized equipment used to interpret them--and have made important progress in both areas during the past year. It is a technique that has already been found useful in several other programs and in a number of industrial applications.

Our maps of the source locations of the signals produced during our large hydraulic-fracturing experiment showed that they were distributed throughout a volume of rock about 3000 feet long, 2600 feet high, and 500 feet thick--about four billion cubic feet of fractured rock. Unexpectedly, this great slab of rock was inclined at about 20 degrees, and passed to the north of the other well--which we had expected the fractures to intersect. This was quite different from the fracturing behavior we had observed in developing the earlier system, a few thousand feet higher at the same site. We think that it must result from the fact that our deeper holes are directed toward a cooling magma body under a nearby extinct volcano--the Valles Caldera--that erupted as recently as about 50,000 years ago. It was of course a disappointment that we did not complete a connection to the other well. However, it is an important discovery that, in the vicinity of a volcanic heat source, hydraulic-fracturing is different from what was expected.

This experience, coupled with advances we have made and will continue to make in technology, has resulted in an improved approach for the development of a hot, dry rock system. In any case, this discovery caused us to change our plans for completing the connection between the two wells. We are returning to the approach that we used a few years ago to complete the prototype system--which is to create a large fracture system from one well and then drill a second well through the fractures. To save the cost of drilling a new well from the surface, we have undertaken to redrill the existing well--turning it away from its old trajectory at a depth of about 9350 feet. Upon completion of repairs to the well from which the fractures were made, the drill rig was skidded to the other well--about 150 feet away. To expose the wall of the hole, a section of steel well casing about 60 feet long was milled out just above 9350 feet. Drilling out of an existing hole in rock as hard as granite is difficult; instead of biting into the rock, the drill bit tends to slide down the wall of the hole. After several unsuccessful attempts to drill out of the hole, we were able to drill out the side and continue for about 90 feet along a new trajectory directed toward the fracture system created from the other well. At this point we reached the maximum safe working depth of the rig, and it was dismissed. This operation took about six weeks and cost $1.1

million. In spite of the difficulties encountered, this high-risk operation--like the well repair in the other hole--was completed on schedule.

Our intention is to continue the redrilled hole for an additional 3600 feet, drilling it through the region in which our acoustic maps indicate that we are most likely to intersect a large number of hydraulic fractures. Our plans for this drilling operation are being reviewed by drilling experts from two industrial organizations with broad experience in drilling and completing geothermal wells. And--again on schedule--we have contracted with a drilling company active in geothermal areas to do the drilling for us, and a modern drilling rig with a 25,000-foot depth capacity is now being assembled at Fenton Hill. Drilling operations should begin this weekend. We expect them to be completed in about ninety days, at an estimated total cost of $2 million. However, directional drilling of deep holes in hot, hard rock is difficult and hazardous, and we cannot expect it to be completely free of problems. Therefore, to cover contingencies, we have reserved an additional $0.5 million to complete the hole.

Upon successful completion of redrilling, it will be necessary to run short-term flow tests through the connected underground system to obtain preliminary information on system behavior and operating conditions. Of particular importance is the pumping pressure needed to maintain the flow rate required to produce heat at a commercially useful rate--say 35 megawatts thermal. If the pressure requirement is excessive, it may be necessary to do additional drilling or hydraulic fracturing before the drilling rig is dismissed. However, we do not expect this to be needed, and this testing will bring us to end of fiscal 1985.

During fiscal 1985, total funding for the Hot Dry Rock Program is

$14.1 million, of which--under an International Energy Agency Agreement--$5 million has been provided by agencies of the governments of West Germany and Japan. This has been sufficient to cover the costs of the field work that I have described and to support the multidisciplinary staff required in conjunction with them. The major activities of that staff include planning and executing such field operations as drilling, fracturing, and flow testing; planning, performing, and analyzing diagnostic experiments; developing and operating the high-temperature instruments required by those experiments; investigating system chemistry and developing chemical methods to investigate other system characteristics; creating and improving system models, and developing predictive capabilities for future hot dry rock systems; and documenting and reporting our results.

However, our 1985 funding has not been sufficient to order some of the major components required to complete the surface system needed to operate a recirculating heat-extraction loop at the pressures, temperatures, and flow rates involved in determining the full heat-production capability of the underground system, nor to initiate construction of that facility. That will have to be done in fiscal 1986, after which we will initiate a flow test--continuing through much of 1987--to explore the problems and demonstrate the capabilities of the completed energy system. To the degree possible, we will reuse components of the prototype system, which are already on site. However, we will need additional higher-pressure, higher-temperature, higher-capacity pumps, piping, valves, flow-control devices, additional heat exchangers, and perhaps gas separators and equipment to remove oxygen from the makeup water (to minimize corrosion of metal components).

Both the components and their assembly in the field will be expensive, and our total funding requirement for fiscal 1986 is $13.5

million. Negotiations are in progress for extension of the International Energy Agreement under which West Germany and Japan each provide $2.5 million to help support the Hot Dry Rock Program. That agreement expires this year, on September 30, and it is not certain that it will be renewed. If the agreement is renewed, our funding requirement from DOE will be $8.5 million. If it is not renewed, we will need the entire program budget from the Department of Energy if the Hot Dry Rock Program is to continue on schedule and at its full and timely effectiveness.

One level of fiscal 1986 funding that has been suggested is $10.5 million, including $5 million from our foreign partners and $5.5 million from DOE. At this level, after procurement of the minimum equipment required to complete an operable surface system, the remaining funds would not be sufficient to complete its construction in fiscal 1986, to enlarge it to the capacity required to demonstrate its full capabilities, or to support all of the existing project staff or the essential activities for which they are responsible. This would extend the project schedule by almost a year, cause a significant reduction of scientific capability, and seriously impact progress in such areas as instrument development, computer analyses and simulations, and geochemical investigations.

Much of the technology so far developed in and for the Hot Dry Rock Program has already been adopted by industry, including such things as improved drilling and well-completion equipment and techniques, high-temperature instruments, and acoustic fracture-mapping methods. However, even more important is the fact that the U.S. program has brought worldwide attention to the facts that hot, dry rock exists at useful temperatures and accessible depths almost everywhere, and that the technology to develop hot dry rock energy systems by hydraulic fracturing is approaching the point at which it can be applied commercially in many places. Interest in such systems has been encouraged by several preliminary economic studies that have already been made and published, and we anticipate it to be increased by a definitive economic study of hot dry rock systems now being made independently by the Electric Power Research Institute.

Strong interest in proceeding with the construction of commerical-scale hot dry rock systems has already been expressed within the United States and in other countries. The possibility of undertaking such a project has been discussed in recent months with representatives of the California State Energy Commission, the Utah State Legislature, and the New York State Energy Research and Development Authority. As evidenced by their direct participation in the U.S. program, the Germans and Japanese believe that hot dry rock systems can be important in their countries, and we have recently been approached by an Australian firm concerning a possible hot dry rock development there. A strong hot dry rock research program now exists in England, there are smaller, complementary programs in several other countries, and a recent report in the technical press states that three hot dry rock projects are being undertaken in the Soviet Union. The magnitude and potential contribution of the hot dry rock energy resource is now recognized domestically and internationally, and there is strong interest in developing and using it.

The U.S. Hot Dry Rock Program is the broadest, most ambitious, and most advanced in the world. We sincerely appreciate the support this committee has given the technology in the past, and hope that this support can be continued so that hot, dry rock can soon be used to improve the energy security of the United States and the rest of the world.

Thank you. I will welcome your comments and questions.

Mr. **Fuqua**. Thank you very much.

In the interest of time, so that we can get the other panel on, we do have some questions in writing that we would like to submit to you. We go in session at 12 o'clock and there will be a vote at 12:01. So we will not disrupt the other panel, we will withhold verbal questions at this time and submit them to you in writing. I know we do have several questions. I thank you for being here. I apologize for the time constraints that we're running into, but we will submit questions to you in writing and would appreciate your prompt response if you could. Thank you very much.

[Questions and answers for the record:]

HARVARD UNIVERSITY
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DIVISION OF APPLIED SCIENCES
HENRY EHRENREICH
CLOWES PROFESSOR OF SCIENCE

June 25, 1985

Congressman Don Fuqua
Chairman
Committee on Science and Technology
U.S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, DC 20515

RECEIVED
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COMMITTEE ON SCIENCE
AND TECHNOLOGY

Dear Congressman Fuqua:

I hope you will forgive this rather late reply to the questions concerning my testimony before the Subcommittee on Energy Development and Applications on March 5, 1985 addressed to me in your letter of May 2, 1985. I did inform Dr. Harlan Watson that my reply would be late because of professional activities that took me abroad. I hope at any rate that they are not too late to be of use.

The questions you have put to me are for the most part addressed in my testimony. My answers to them are therefore rather brief and should be read in conjunction with the formal statement I have previously submitted to your committee.

1. I believe that the topics covered by the present National Photovoltaics Program are well balanced between science and technology and in that sense the program is sound. It is however seriously underfunded. I believe an increase of 25% is mandatory if the program is going to push photovoltaic technology forward. I should add that the scientific qualifications of many of the people I know who are associated with the program both at SERI and elsewhere are very high.

2. The near-term PV silicon technology, which is currently being employed, is well developed and probably will show only small improvements. It is this technology that is being employed in facilities such as SMUD under present construction and other similar projects. This situation is likely to persist until 1990 or so. One might wish for increasing national efforts to make this technology commercially available to developing countries. As a member of the OSTP sponsored Senior Commission on Indo-US Scientific and Technical Cooperation at the beginning of 1984, I urged that US industry try, with government cooperation, to increase exports of silicon photovoltaic modules both to India and other countries in similar circumstances. It is clear that even a small amount of electric power in a village can have an enormous beneficial influence in improving lifestyle. It was interesting to observe that Mr. Gandhi in his recent visit made it clear that India was interested in large scale purchases of US manufactured computers. Perhaps some thought should also be given to photovoltaics in that context. The intermediate market which would be generated by such purchases is essential for the growth of the photovoltaic industry in this country and forms a prerequisite to the "far-term PV technologies" referred to in your question. I believe that these technologies will include the more extensive use of concentrators in conjunction with silicon or gallium arsenide

cells. There might also be some application of amorphous silicon in tandem cells for power applications, but it is too early to be sure. (In this discussion I am excluding from consideration the Japanese market involving the use of amorphous silicon cells in hand-held computers and watches which is likely to saturate rather quickly.)

The scenario I have described above is quite consistent with the issues addressed by the present photovoltaic program in this country.

3. I do not know enough about the details of the SERI funding program to know how well universities are really being utilized. Because of inadequate funding the question is perhaps moot. As the energy crisis has abated, industry has unfortunately cut-back appreciably on its own photovoltaic programs. Exxon, for example, liquidated its company (Solar Power). So has RCA. Arco and Solarex appear to be the two chief actors. DOE appears to be utilizing these resources adequately.

4. The mix of basic and applied research in the present program seems to be about right. Most of the basic advances in the understanding of semiconductors that might also be useful in PV applications is currently being made in the computer and communications industry. Much of that information should certainly be transferable for cells made in the far-term technology, when concentrators are likely to be important.

5. Industry, together with JPL, appear to be addressing materials engineering aspects in a manner consistent with the scale of its manufacturing activities. The materials science aspects are best addressed by SERI and research programs conducted at universities under SERI's sponsorship. Furthermore, government support, according to present-day thinking, is more appropriate for the materials science aspects. Within this framework, industries will have to fend for themselves in addressing the materials engineering aspects. Nevertheless, the encouragement of the growth of an intermediate photovoltaic market through tax incentives, a promotion of contacts with other countries that might benefit immediately from modest photovoltaic installations would lead to increasing an entirely appropriate emphasis on the engineering aspects. Needless to say, the solution of these problems is fundamental to the growth of a healthy US industry and for our long term energy prospects. Our national photovoltaic program is presumably directed towards deployment of PV installations in the United States. Sooner or later an energy crisis will confront this country again. In states like Arizona and California, particularly, the availability of sizeable PV stations supplying electric power at affordable prices during the first decade of the next century may be of crucial importance.

On another subject, permit me, as Director of Harvard's Materials Science Laboratory, to express my pleasure at your active involvement in the Materials Science and Engineering Study discussed by you and others at the NAS on March 7-8. Other commitments unfortunately prevented me from participating in the meeting. I am, however, following developments with the deepest interest, and shall be happy to be of help if it is needed.

Sincerely yours,

Henry Ehrenreich

Henry Ehrenreich

HE/cmm

SMUD

SACRAMENTO MUNICIPAL UTILITY DISTRICT ☐ 6201 S Street, P.O. Box 15830, Sacramento, CA 95813; (916) 452-3211
AN ELECTRIC SYSTEM SERVING THE HEART OF CALIFORNIA

May 10, 1985

HON DON FUQUA CHAIRMAN
COMMITTEE ON SCIENCE AND TECHNOLOGY
U S HOUSE OF REPRESENTATIVES
SUITE 2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON DC 20515

SUBJECT: SMUD RESPONSE TO QUESTIONS FROM THE SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

In response to your letter of May 2, 1985, I have prepared the attached answers to the questions from the Subcommittee in order to supplement my testimony of March 5, 1985.

You may be aware by now that on April 18, 1985, the SMUD Board of Directors voted to accept my recommendation that Phase 3 of this project be indefinitely postponed. This action was based on the fact that bids received for the Phase 3 photovoltaic panels exceeded the project budget, and would lead to an overrun of approximately $4 million. The recommendation and Board action reflect the approach SMUD has applied to this project since its inception. Our position has been that the cost goals set for the project must be adhered to. We consider the lack of progress in reducing photovoltaic panel costs to be a signal that the PV industry is simply not ready to support projects of this type. Thus, postponement appears to be the only appropriate action.

On behalf of the District, I would like to thank you and the members of the Committee for your active support of this project. I think that the record clearly shows that this has been one of the most successful partnerships of its kind. Together the federal government and this utility have substantially furthered the progress of photovoltaics in central station applications. I hope that we have set a precedent for further cooperative efforts in the future.

Mark W. Anderson
Project Manager

Attachments

cc: Hon. Vic Fazio

Attachment I

Response to Questions for Mr. Anderson

1. Question: What has been the first phase's actual performance compared with its predicted performance?

   Answer: Attachment II is a copy of a bar graph showing PV1's predicted vs. actual performance based on actual insolation data, through April 30, 1985.

2. Question: What problems have been encountered in the first phase's operation to date and how are they being resolved?

   Answer: The initial seven months operating period has also not been without its problems. The problems are primarily confined to two areas: the PCU and the DC ground detection system. There have been other problems, but they have not reoccurred. For example, a resistor in an array drive control circuit failed making that drive inoperative. As a result, we had to remove an entire source circuit from service for two months until we could obtain a replacement resistor. In another instance, we experienced an open circuit in the interconnecting wiring of a PV panel causing damage to four modules from the resultant overcurrent back biasing the modules.

   Problems with the PCU began almost immediately after commercial operation with the failure of the 12kV circuit interrupter to close. It took approximately six weeks to resolve the problem which turned out to be a McGraw-Edison design error with the mechanical linkage. The problem has not reoccurred since the unit was modified. Problems also occurred with the SCR firing Boards, reverse power relay, and the ground detection relay. The problems seem to center around failed or out of tolerance components and misapplication of relays due to lack of understanding of system interaction. The reasons for the trips could not be determined until T&D Operations installed an oscillograph to monitor the PCU. Consequently, we were plagued by these spurious trips for almost three months, drastically affecting performance. Also, the unit was down for most of the month of November to install the oscillograph.

   The other problem severely affecting operation was nuisance trips by the ground detection system. We found that uneven illumination or moisture can cause current imbalances in the neutral that appear as grounds. The problem can be solved by adjusting the sensitivity of the detection circuit. The concern is to determine the optimum setpoint that will avoid nuisance trips without limiting our ability to detect ground faults. Since the first of the year, the plant has performed well. Output in February was 108% of design prediction based on the Fresno Typical Meteorological year insolation values and there have been no significant problems.

3. Question: What was the cost of the PV panels in the first phase and second phase, respectively? What is SMUD's cost goal for the third phase PV panels?

Answer: Panel cost experience and goals are shown below, in dollars per AC watt, delivered to the utility grid. This number allows for energy lost in collection within the array field, DC to AC conversion, and losses due to ambient temperature conditions. On PV1 and PV2 we estimated these aggregate losses to be 20%. Operating experience on PV1 has shown that they are closer to 25%, so we used the latter figure for PV3.

Phase	PV Panel Cost ($/AC Watt)
PV1	$7.52
PV2	6.24
PV3	5.00 (Goal)*

*Estimated aggregate cost for PV3 panels using an assumed split between the two lowest responsive bidders of 4.25 MW (DC) and 2.0 MW (DC), respectively, was $6.02 per AC Watt.

4. Question: You note that SMUD has increased the time allowed for delivery of the PV3 panels. How much time was allowed in the original request for bids and how much longer has this been extended?

Answer: The original bid request called for panel contract award in March, 1985, release for fabrication in June, 1986, upon completion of qualification tests, design approval, and receipt of bids on all major construction and procurement contracts; and final panel delivery by December 1987.

In the second round of bidding we changed the schedule to: contract award in April, 1985; release for fabrication November, 1985; and final panel delivery by December, 1987. This extended the fabrication period by ten months.

5. Question: When will SMUD come to a decision whether or not to proceed with the third phase of the project?

Answer: On April 18, 1985, the SMUD Board voted to indefinitely postpone work on PV3 until such time as project costs fall back into line with the project plan. We recognize that this delay will likely mean a loss of the funds Congress has already appropriated for this project. We further recognize that it will be SMUD's responsibility to initiate action for a new appropriation, if we elect to re-enter the project in the future.

6. Question: Because of the drop in world oil prices, is SMUD facing level or decreasing avoided costs for the foreseeable future, and if so, how likely is it that you will proceed with the project?

Answer: SMUD, and all of Northern California, is facing a future where base-load energy will be relatively abundant and the price will be level. However, peak-period energy and capacity are currently in short supply, and the situation will likely get worse, driving the price of this energy and capacity upward. This is due to the fact that there are a number of constraints on a California utility's ability to add peaking facilities. Most of these constraints are regulatory and are not a function of oil prices or plant construction costs. This situation would enhance the value of a PV project to utilities like SMUD, if our daily peak loads coincided with the generating schedule of a PV plant. However, conservation efforts have served to move our peak loads from afternoon to mid-evening, when the PV plants cannot generate. This fact, in combination with the low price of off-peak energy, makes it difficult to predict when (or if) SMUD will re-enter this project in the future.

7. Question: What have been the contributions of this project to the National Photovoltaics Program?

Answer: The contributions of this project to the National Photovoltaics Program can be listed under two separate headings: Technical Developments, and Commercialization.

Attachment I

Page 4

Technical Developments:

The basic management philosophy of this project was to treat it as we would any other power plant project: 1) adhere rigidly to budget and schedule, and 2) adhere to existing utility standards for reliability and durability. While these requirements may seem limiting to an emerging technology, they forced some very positive developments:

- The system was built to a much higher standard of reliability and durability than any previous project, yet also at a substantially lower cost.
- Adherence to the management philosophy caused supporting players (primarily equipment suppliers) to force development of newer and better products, again at record low prices. For example, the PV panels, DC-to-AC invertor, and the balance of system were all built to higher stands of efficiency and performance, but at much lower costs than previously demonstrated.
- The project also demonstrated the advantages of the single-axis tracking flat-plate design. This design offers the higher energy generation and operating flexibility of more expensive 2-axis and concentrator systems, but with the advantages of much lower costs and higher reliability.

Commercialization:

Exposure of the PV industry to the needs of the electric utility industry, through this project, and the like exposure of the utility to the needs of the PV industry forced both sides to come to grips with real issues which must be resolved before PV achieves commercial status. Numerous examples of this can be cited, but the most significant is this: the approach SMUD took to this project placed control of every aspect of the job into the hands of the utility, the end-user of the PV system. This was the first time a PV project had been built in such a fashion. This is an important first, since it is the first time a PV project has been controlled from start to finish by its owner and operating entity. Previously, projects were controlled by other players: equipment vendors, designers, or government agencies. The unfortunate truth is that none of these entities is as willing to take the hard-nosed, long-term view of the project that a utility-owner will.

Attachment I

Page 5

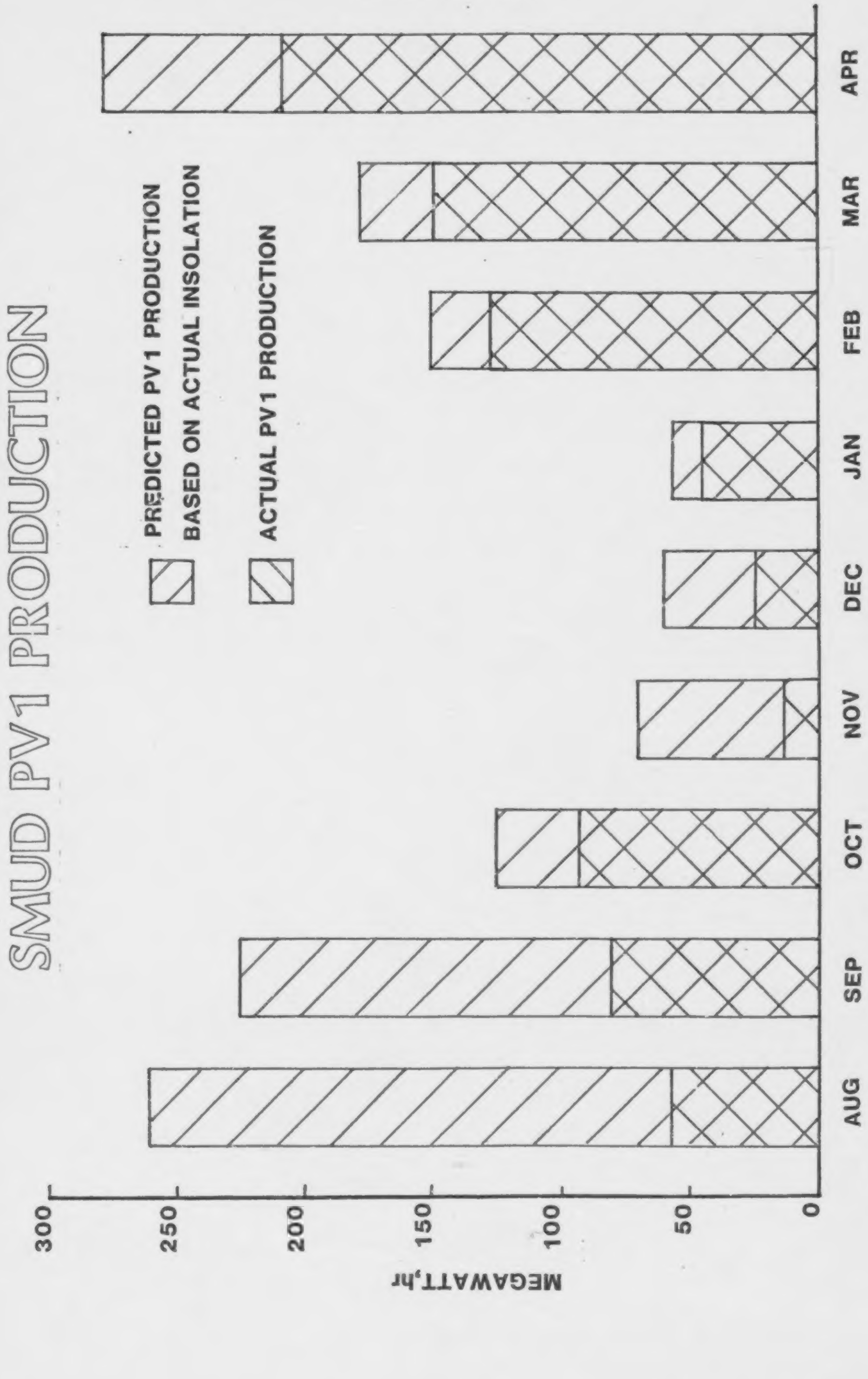
In this case the utility demanded, and received a higher level of performance from each of the other players, but at a lower cost.

Also, the utility got a better understanding of the constraints on the PV industry, which limit the pace of commercialization. This better understanding, on both sides, will ultimately result in a more realistic appraisal of photovoltaic's potential for utility applications, a development which is clearly in the best interests of the nation.

8. Question: With regard to the curve shown on Attachment I of your testimony, where would the point PV3 lie given the current quotes received?

Answer: That point would be 10% higher than the point shown on Attachment I. In other words, the $8.00 per AC watt budget for PV3 would become $8.80 per AC watt, in 1987 dollars.

Attachment II



March 5

ADDITIONAL QUESTIONS AND ANSWERS

MICHAEL E. BERGER, DEPUTY ASSOCIATE DIRECTOR
LOS ALAMOS NATIONAL LABORATORY

QUESTION 1: According to DOE's submittal, $7.5 million was provided in FY 1985 for Hot Dry Rock research. Additionally, a recent programming request by the Department provided $2.0 million for the Fenton Hill project. The DOE request for FY 1986 is $5.5 million. Will this funding allow sufficient funding for construction of the thermal loop?

ANSWER: Principally because of the costs of components, surface circulation and heat-dissipation system, the total FY 1986 funding required for the Fenton Hill Project is $13.5 million. If cost-sharing by West Germany and Japan continues at its present level of $5 million annually, the FY 1986 funding required from DOE will be $8.5 million (compared to $9.5 million total from DOE in FY 1985). Even with large reductions in scientific staff and in essential research, $5.5 million from DOE would not permit completing the surface part of the thermal loop in FY 1986.

QUESTION 2: If you are successful in completing the thermal loop in the Hot Dry Rock program, will that enhance the cost sharing by the Japanese and German participants?

ANSWER: Successful completion of the thermal loop would greatly increase the probability that West Germany and Japan would continue to share project costs and continue as International Energy Agency (IEA) partners, since long-term operation of the completed loop will provide essential operating and maintenance data on the economic and engineering viability of potential commerical hot dry rock geothermal energy systems.

QUESTION 3: Does the International Energy Agency Cooperative Agreement contractually require funding beyond that provided to date? If so, how much?

ANSWER: The present International Energy Agency Agreement expires at the end of FY 1985 and, unless it is extended, no funding for the Fenton Hill project will be provided by West Germany and Japan after September 30, 1985.

QUESTION 4: When do you anticipate DOE participation will be completed?

ANSWER: If adequate funds are provided by the Congress and IEA partners to maintain existing schedules, the Fenton Hill project and DOE participation in it will terminate in FY 1988.

PANEL 2; ELECTRIC UTILITY TECHNOLOGIES FOR THE 1990'S

Mr. **Fuqua**. The next panel on electric utilities technologies for the 1990's, includes Dr. Peter D. Blair of OTA, Commissioner Stephen Wiel, of the Committee on Energy Conservation, National Association of Regulatory Commissioners, and Mr. Scott Sklar, director of Government relations, Solar Energy Industries Association.

And Dr. Blair, we'd be pleased to hear from you at this time.

STATEMENT OF DR. PETER D. BLAIR, PROJECT DIRECTOR, ENERGY AND MATERIALS PROGRAM, OFFICE OF TECHNOLOGY ASSESSMENT, WASHINGTON, DC

Dr. **Blair**. Thank you. Mr. Chairman, members of the committee, thank you for the opportunity to share with the subcommittee some of the findings of OTA's ongoing study, "New Electric Power Technologies, Problems and Prospects for the 1990's." This study was requested by your committee and examines the circumstances that could lead to the—to substantial deployment of new electric generating technologies and load management in the 1990's. We expect to release the study later this spring, so the purpose of my testimony today is to provide some insights from the analysis underway; particularly those that deal with investment decisions and the rate of deployment of these technologies through the 1990's. In the interest of time and deference to the lateness of the hour and growling stomachs and the like, we will—I'll be quite brief. We've provided to the staff a good deal of additional supplementary material from the assessment to date, such as the benchmark comparision of costs and performance figures of the technologies we're considering, as well as some preliminary insights on the role of the renewable energy tax credits in commercializing new technologies and some conclusions on R&D priorities that have emerged in the course of the study.

Well, our charge really begins by observing the recent history of the electric power business, particularly over the last decade, which has been—turned out to be a period of unprecedented change in the industry. As a result we're observing utilities now considering a much broader range of strategic options, including life extension of existing facilities, increased purchases from neighboring utilities, diversification, increased reliance on load management and conservation and finally, I guess our principal focus here, increased attention to smaller scale, modular designed technologies from both conventional and alternative sources. All these options are aimed at reducing uncertainty and maintaining flexibility, a key word, I guess, in utility planning these days.

While OTA's assessment focuses on two groups of developing generating technologies, that while not fully mature, could figure importantly in the selection of technologies, either by utility or nonutility producers in the 1990's. The first group, the sort of utility oriented technologies, consists of new baseload coal technologies like the large atmospheric fluidized bed combustors and integrated coal gasification and combined cycle units, compressed air energy storage, larger geothermal plants, utility fuel cells and finally the solar thermal central receivers.

The second group consists of smaller scale technologies suitable for nonutility applications as well. Small AFBC and fuel cells in co-generation applications, as well as of course the renewables in small geothermal plants and other solar powered technology, such as photovoltaics and the parabolic dishes. While virtually all of the technologies that we've considered offer at least the potential of sizable deployment beyond the turn of the century we've concluded so far that at the current rate of the development, very few of the technologies are likely to be extensively put into place in the 1990's.

In the first group this may be attributable to long preconstruction and construction leadtimes, while in the second group technologies, of course, have shorter lead times and are often smaller in scale, but for increased contribution in the 1990's most of the technologies, in our view, would require stepped up development to reduce costs as well as to resolve cost and performance uncertainties that concern both utility and nonutility investors alike.

So, if the technologies that we've analyzed are to contribute to electricity supply in the 1990's in the event of increased load growth, the steps necessary to make them available vary somewhat according to technology and this is a particularly important consideration since commitments to traditional generating plants would have to be made now in order to service the load growth in the 1990's, because of long leadtimes.

For accelerated deployment, the first group would require, of course, resolving cost and performance uncertainties within the next several years and to shorten the leadtimes of early commercial units. In the—these uncertainties in cost of performance stem largely from the lack of commercial experience and in the wake of utilities experience with nuclear power, many utilities, in particular, are particularly wary of new technologies and impose rigorous performance tests on investments, so the conservatism confers added importance to advanced demonstration projects, both in adequate duration and the nature of the program itself, that is the degree of utility involvement. So, given these conditions that might be fulfilled in current—that is current RD&D programs, schedules for the basic designs of AFBC, IGCC and utilities scale geothermal plants seem to be adequate for these technologies to be ready in the 1990's, however, the transition from the demonstration to early commercial units would have to be accelerated. In particular, the leadtimes of early commercial projects, in many cases, have been longer than anticipated and with accelerated demand growth utilities would be pressing to reduce these leadtimes considerably.

For the second group, that is the smaller scale renewable technologies, resolving cost and performance uncertainties is of particular concern and one approach might be to more sharply focus Federal R&D efforts. Other approaches are to supplement direct Federal efforts in technology development in the form of, for example the—well, the reemergence of nonutility power generation in recent years is serving, of course, as a very important test bed for new generating technologies and our analysis to date shows that the renewable tax credits, as well as the recovery of full avoided cost under PURPA, by nonutility power producers have been crucial in this initial commercial development.

In particular with declining Federal support, the renewable tax credits have actually taken on a new dimension, where they are actually supporting research and development in the field, rather than their original design of commercial—support of commercial applications of mature designs.

So, to quickly sum up, if increased contribution to electric power generation of technologies we've considered is desired in the 1990's accelerated or focused R&D, particularly in demonstration for many of the technologies we've considered, would be required.

For larger scale technologies and utility applications, a cooperative industry and Government demonstration efforts have a very good track record. However, successful technical demonstration alone may not be sufficient. Both technical development and early commercial applications of many of the smaller scale technologies have been aided considerably by investment incentives, such as favorable tax treatment and PURPA, continuation of these measures could assist accelerated contribution, but again such efforts alone probably would not be sufficient to insure timely development and substantial application in the 1990's.

So, in sum I guess we feel that many of the technologies we've considered could be available, should they be needed in the event of anticipated load growth, but it's going to require some additional or perhaps refocused effort and our assessment will deal with that issue in some detail.

[The prepared statement of Dr. Blair follows:]

TESTIMONY OF PETER D. BLAIR
PROJECT DIRECTOR, ENERGY AND MATERIALS PROGRAM
OFFICE OF TECHNOLOGY ASSESSMENT

before

Subcommittee on Energy Development and Applications
House Committee on Science and Technology

March 5, 1985

Mr. Chairman,

Thank you for the opportunity to share with your subcommittee some of the findings of the Office of Technology Assessment's study, New Electric Power Technologies: Problems and Prospects for the 1990's. This study, which was requested by your committee, examines the circumstances that could lead to substantial deployment of new electric generating technologies and load management in the 1990's; we expect to release the study later this spring. The purpose of my testimony today is to provide some insights from the analysis underway at OTA, particularly those that deal with the rate of deployment of these technologies through the 1990's.

The decade of the 1970's was a period of unprecedented change in the U.S. electric power industry. Beginning with the Arab oil embargo, the environment within which utilities made investment decisions changed from a stable and seemingly predictable forecast of past trends to a highly uncertain and complicated maze of interrelated economic, regulatory, and technology decisions. During this period some electric utilities were brought to the brink of bankruptcy when forced to cancel large unneeded power plants, commitments to which were required long before it was fully realized that electricity demand had been considerably overestimated. The eroding revenue base which accompanyed declining and uncertain load growth, and the large costly construction programs underway left the industry, for the most part, struggling financially as bond ratings and stock prices fell precipitously.

As utilities face the 1990's and continued highly uncertain load growth, the experiences of the 1970's have forced them to become much more sensitive to the financial risk of guessing wrong and commiting to large central-station coal and nuclear plants. Even now in the mid 1980's as many utilities have recovered from the financially troubled period of the 1970's, the scars left from it have forced them to reexamine their traditional business strategies. Conditioned by the experiences of the 1970's, even the process by which utilities initiate, analyze and implement investment decisions has, in some cases, undergone fundamental change.

Power system planners now work much more closely with financial planners to carefully analyze the cash flow implications associated with alternatives. Flexibility in accommodating unanticipated changes in demand, capital cost, interest rates, environmental regulation, and a host of other factors is a key consideration. In particular, utilities now consider a much broader range of strategic options including life extension and rehabilitation of existing generating facilities, increased purchases from and shared construction programs with neighboring utilities, diversification to non-traditional lines of business, increased reliance on load management and conservation activities, and, finally, increased attention to smaller scale power production from a variety of both conventional and alternative energy sources. All of these options are aimed at reducing uncertainty and maintaining flexibility in making investments in an uncertain decision environment.

THE ROLE OF NEW GENERATING TECHNOLOGIES

Overview

OTA's assessment focusses on a group of developing generating technologies that, while not yet fully mature, could figure importantly in the selection of technologies by either utility or non-utility producers in the 1990's. The technologies considered include integrated coal gasification combined cycle plants (IGCC), atmospheric fluidized bed combustors (AFBC), fuel cells, photovoltaics (PV), solar thermal, geothermal, wind, compressed air energy storage (CAES), advanced utility-scale battery storage systems, and load management.

Virtually all of the technologies considered in this assessment offer the potential of sizeable deployment in electric power generation applications beyond the turn of the century. Despite this long term optimism, however, at the current rate of development very few of these technologies are likely to be extensively put in place in the 1990's. Common to the deployment of all electric generating technologies is the need for planning, design, licensing, permitting, other preconstruction activities, and finally construction itself. These steps with some technologies can take long periods of time--leadtimes of eight to ten years or more in some cases. For deployment in the 1990s, this means that there may be as little as five or six years to adequately develop the technology, and to establish in the minds of investors that the technology's costs, performance, and other attributes fall within acceptable ranges. Therefore, the prospects for a substantial contribution over this period are likely to be sharply limited by long leadtimes, and, therefore, the limited time available to fully develop the technology (if necessary) to the point it is considered acceptable by utilities.

Specific Generating Technologies

Because of these two conditions, the current outlook for the 1990's of Integrated Coal Gasification-Combined Cycle (IGCC) technology appears quite limited. This outlook is in spite of the long term promise of IGCC technology and the fact that a demonstration unit (160 MW) has been operating well since mid-1984. A major concern is that a fully commercial IGCC plant will probably have a leadtime of 8-10 years, primarily because of regulatory considerations. This means that a commercial IGCC unit would have to be started in the next five or six years. Some utility investor commitments may be made within that period of time, but these will be relatively few in number and extensive orders are unlikely until the mid- to late-nineties at the earliest. At the current development pace, cost and performance uncertainties for most investors still seem to be too high. Moreover, it is likely that smaller (100MWe and below), less risky Atmospheric Fluidized Bed Combustors (AFBC) will provide an attractive alternative to the IGCC during this period.

Large (about 150 MWe), "grass-roots" (i.e., not retrofits of existing facilities) AFBC's for generating electricity also appear to be subject to long-lead times. Moreover, unlike the IGCC, a large AFBC demonstration unit probably will not be operating until 1989. It now appears unlikely that the operation of that unit will be sufficient to justify large numbers of orders within the first few years of the 1990s. Favorable experience with smaller cogeneration units and retrofit units which will be in service by then, however, may provide commercial experience to accelerate deployment of the larger units.

Another technology with only limited prospects in the 1990's because of long lead times is Compressed Air Energy Storage (CAES). The large scale version of this technology (often called maxi-CAES) currently has an estimated leadtime of over eight years. Moreover, while commercial installations are operating in Europe, no plant yet exists in the United States. Despite strong evidence that the technology offers an economic storage option, CAES is unlikely to be the target of much investment until a demonstration plant is built. No plans for such a plant currently exist, and even the immediate initiation of a demonstration facility may not provide sufficient operating experience to stimulate extensive deployment of the technology in the 1990s. A demonstration project should prove the technology, but peculiar siting problems and unfamiliarity with the CAES concept may still limit early application. A smaller alternative--mini-CAES--promises to have a much shorter lead time. But here too, unless a demonstration plant is started in the next few years, extensive deployment is improbable before the end of the century.

Other technologies examined in this study have shorter leadtimes and often are smaller in generating capacity, although the cost and performance uncertainties are still important concerns in the eyes of utility investors. Many of these technologies, however, can qualify as small power producers employed in non-utility power generating projects operating under the provisions of the Public Utility Regulatory Policies Act. Among these are some which, under some circumstances, could contribute substantial quantities of electric power in the 1990s.

The existence of a wide variety of markets (many made possible by PURPA) and interested investors outside the electric utilties increases the likelihood that many of these technologies will be deployed. For this reason, initial contribution is likely to be heavily influenced by the use of avoided costs, a calculation required by law for utilities to use in negotiating the "buyback rates" offered by utilities to non-utility power producers. Should the costs be low or uncertain, technological development and application will, of course, be retarded. Conversely, high avoided costs, stimulated perhaps by rising oil and gas prices or shrinking reserve margins, might substantially accelerate their contribution.

Foremost among these technologies are small (below 100 MWe) AFBC plants in cogeneration applications and larger (100-150 MWe) AFBC retrofits to existing coal-fired power plants. By 1990, plants of both types will be operating. Seven commercial cogeneration plants have been started by non-utilities; and two large utility retrofit projects are underway. Further, these first plants appear capable of producing electric power at lower costs than their solid-fuel burning competitors (including the IGCC and large electric-only grass-roots AFBCs) in the 1990s. The prospects are good that additional orders--perhaps mostly from non-utilities--will be forthcoming and that large numbers of the units could be operating by the end of the century.

While the prospects for wind turbines are clouded by the anticipated termination of the renewable energy tax credits (RTC) and other potential tax changes, the longer-term outlook nevertheless appears promising. By the end of 1984, an estimated 700 MWe were in place in windfarms in the U.S. Over the early 1980's, capital costs have been dropping rapidly; and performance has improved quickly. Improvements are expected to continue, and the cost of electric power even from unsubsidized wind turbines in high-wind parts of the country may be considerably less expensive than power from many of its competitors, as the current generation of small wind machines is scaled up by the industry to the next generation of medium-sized machines.

Wind turbine improvements have been greatly assisted by favorable federal and state tax treatment, and by relatively high avoided costs in California. Changes in either would diminish the rate of deployment and technical progress, although both are likely to continue after the expiration of the RTC. It appears unlikely, however, that such deployment and technical progress would continue if removal of the RTC were coupled with lower avoided costs and removal of accelerated depreciation allowances (ACRS) and investment tax credits (ITC) in the Federal tax code which would result in project rates of return below levels that would attract investment.

While geothermal development has been substantial compared to renewable technologies, virtually all of this development has occurred at The Geysers in California, a unique high quality dry steam resource (one of only seven known in the world) that can be tapped with mature technology. All other geothermal resources in the U.S. are considerably less attractive and must employ more sophisticated and less developed technology to generate power. However, several of these developing geothermal technologies, in particular dual flash and binary systems, are currently being demonstrated on a small scale and show promise for commercial applications in the West. Current evidence indicates that the equipment is very close to being commercial, and that cost and performance will be competitive. These conditions, coupled with the fact that the technology can be put in place with leadtimes of 5 years or less, suggest that it could produce electric power in the West in sizeable quantities by the end of the century. As is the case with wind power, the growth rate of geothermal power will be sensitive to Federal tax policy. Termination of RTC or removal of ACRS provisions and ITC's might slow deployment levels substantially, although, again, industry activity probably would continue.

OTA expects initial commercial application of fuel cells to appear in the early 1990's. The large and potentially varied market (it includes both gas and electric utilities as well as third-party cogenerators), very short lead times, factory fabrication of components, and a variety of operational and environmental benefits all suggest that when cost and performance of fuel cell power plants become acceptable, deployment could proceed rapidly. The principal obstacle to extensive contribution seems to be insufficient initial demand to justify commercial production of fuel cells. For such demand to appear in the 1990s, extensive commercial demonstration in the late 1980's will probably be required.

The development rate of photovoltaics (PV) has been considerable in recent years, but the technical challenge of developing a PV module that is efficient, long-lasting and inexpensive remains. While technical progress and deployment of photovoltaics in the U.S. are likely to be slowed by termination of the RTC or by other changes in the tax law, or by declining avoided costs, industry activity is likely to remain intense. Aided by interim markets of remote applications and consumer electronics, PV's could develop to the point where competitive grid-connected applications at least begin to appear in the 1990's.

Of the solar thermal technologies, solar parabolic dish technologies offer the most promise over the next 10-15 years. They are being pursued by many different developers, and in many different forms. Characteristics of some of the designs indicate that they could be rapidly put in place in areas of high levels of direct insolation, such as the Southwest. Our analysis suggests that costs of power generation, if energy storage is not necessary, in these regions and using these designs could be very close to those of conventional alternatives, and to developing technologies such as photovoltaics and fuel cells. Some demonstration and subsidized commercial units already are operating. Commercial application, however, will require further demonstrations of the technologies over extended periods of time; such demonstrations must be started no later than 1990 if the technologies are to be considered seriously by investors in the 1990s. The likelihood of such demonstrations, however, appears now to depend on the availability of some kind of subsidy. In particular, development of the technology to date has depended heavily on the RTC.

Several designs of solar thermal parabolic troughs are being developed and a commercial unit, also benefiting from the RTC, was operating in Southern California by early 1985. Troughs, and other solar thermal variations, including central receivers and solar ponds, however, while showing long term promise, are unlikely to be competitive with other power generation alternatives or have sufficient commercial demonstration experience to yield any significant contribution through the 1990's.

Considerable technical development and demonstration to resolve performance uncertainties remains to be completed before extensive use of advanced battery storage systems can be anticipated. At the current rate of development, this appears unlikely through the 1990's. If the technical problems can be resolved, the projected short lead times coupled with further cost reductions associated with mass production could lead to rapid deployment in electric utility applications. Of the candidates, lead-acid and zinc-halogen batteries appear to show the most promise.

Load Management

Load management is manipulation of customer demand by economic and/or technical means to alter the time behavior of that demand. It is different than conservation which reduces total demand through more efficient use of energy or lowering levels of use. While for many utilities load management is not seen as a permanent replacement for new capacity, it is now widely employed by some utilities that seek to improve load factor (ratio of average to peak load). Since base load generating equipment is generally more efficient that peak load equipment, the principal goals of load management are to permit a higher proportion of demand to be served by lower cost electricity (from base load sources) and to defer the need for costly new generating capacity. A potentially important feature of load management is that it can reduce future load growth uncertainty if the saturation and use of load management devices can be predicted accurately. Any strategy employed to manage customer load includes components either (or both) to (1) encourage shifting demand to off-peak periods or (2) inhibit demand during peak periods. In this assessment we consider only technology-based direct load control technologies employing advanced meters and utility-owned or controlled load control systems.

Based on the results of current load management programs and on-going experiments, load management technologies are expected eventually to cost far less than many conventional generating alternatives. In many instances, however, the costs of load control devices cannot be driven down without substantial utility and/or consumer demand which in turn would enable manufacturers to realize volume production economies.

Widespread deployment of load management in the 1990s will depend on continued experimentation by the nation's utilities and their customers, the refinement of load management equipment and techniques, and the development of new institutional arrangements. These steps are expected to be time consuming, but with concerted effort by the utilities in the extensive use of load management in the 1990s could result. While many utilities presently are actively pursuing load management, most utilities have not progressed beyond experiments. Whether these experiments will lead to major commitments to load management is still uncertain. Commitments will depend on the expected cost and performance of the load management system, the characteristics of the utility's supply of and demand for electric power, the attitudes of utility decision-makers, and on public utility commission actions.

SENSITIVITY TO FUTURE LOAD GROWTH

If electricity demand growth declines to an average annual rate of 2.5 percent or less through the 1990's--the average annual growth rate from 1973 to 1984 was 2.5 percent--utilities' needs for new generating capacity are likely to be modest enough to be served by the short-term strategic options mentioned earlier, and by adding a relatively small amount conventional generating technologies. In that case the development schedules and lead times currently associated with the alternative technologies discussed above need not be significantly accelerated. It is possible, however, that electricity demand may grow faster, in which case utilities in some U.S. regions may require substantially more new generating capacity than can be supplied in this manner. For example, the Energy Information Administration in their most recent Energy Outlook forecasts a 3.2 percent per year growth rate to 1995 as their mid-range projection. Also, in our study, Nuclear Power in an Age of Uncertainty, we estimate that electricity demand could grow as high as 4 percent per year.

In addition to accelerated demand growth, a variety of future circumstances affecting environmental quality, fuel availability, and economics could enhance the attractiveness of certain technologies. For example, acid rain legislation could elevate the position of advanced coal conversion technologies such as Atmospheric Fluidized Bed Combustors and Integrated Coal Gasification-Combined Cycle systems.

Under circumstances such as accelerated load growth, the interest in conventional and developing technologies that offer the flexibility of short lead times, modular design features, as well as the long-term promise of cleaner, more efficient utilization of abundent coal resources might be sharply increased. At the current rate of development, however, most of these technologies will not be in a position to meet load growth in the 1990's.

Steps for Accelerated Development and Deployment

If the technologies analyzed in this study are to contribute to electricity supply in the 1990's in the event of increased load growth, the steps necessary to make them available in that time vary according to the technology. In particular, we consider two basic groups of new generating technologies, each of which would be affected differently by circumstances of increased load growth.

The first group of technologies consists of base load coal technologies, i.e., large AFBC and IGCC, envisioned only in electric utility applications, compressed air energy storage, large (greater than 50 MW) geothermal plants, and utility-owned fuel cell power plants. The second group consists of small AFBC and fuel cell plants in non-utility cogeneration applications, and solar, wind and small geothermal power generating technologies.

With the first group of technologies, the two principal developments that are necessary are, first, to resolve cost and performance uncertainties within the next 5-6 years, and second, to shorten lead times of early commercial units.

Uncertainties in cost and performance stem largely from the lack of sufficient commercial operating experience to satisfy non-utility investors and utility decision-makers. Utility decision-makers, in particular, in the wake of their experience with nuclear power, are now particularly wary of new technology and impose rigorous performance tests on technology investment alternatives. This conservatism confers added importance to advanced commercial demonstration projects. We estimate that demonstration periods of at least six months for small (several megawatt) generating systems and up to five years for large (hundreds of megawatt) systems generally are be required before utilities would be willing to make substantial investments in new technologies. Moreover, the nature of the demonstration program, i.e., the degree of utility participation, project management responsibility, and the applicability of the program to a wide variety of utility circumstances, is of equal importance.

Given these conditions, cost and performance uncertainties are already being addressed at an adequate pace for AFBC, IGCC, and geothermal plants with demonstration projects currently underway. Variations in basic design --for example different gasifiers or alternative fuel feed systems--or other enhancements may be important, however, and that would require additional research and development. But no significant acceleration of existing research and development schedules for the basic designs would be required for these technologies to be ready for the 1990's. The transition from demonstration to early commercial units, however, would have to be accelerated if the technologies are to be used in serving load growth in the 1990's.

To date, the rate of deployment of many new generating technologies is being lowered because lead times being experienced by early commercial projects have been longer than anticipated, largely due to regulatory delays. As regulatory agencies become more familiar with the technologies, and their environmental impacts become clearer, delays should shorten, although this is by no means guaranteed as evidenced by the history of other generating technologies. With accelerated demand growth, however, utilities would be pressing to reduce these lead times. Action to educate regulators in the course of demonstrations might reduce the lead times of early commercial units.

The second group of technologies examined in this study generally have shorter leadtimes and often are smaller in generating capacity. Hence, long lead times are not expected to hamper early commercial applications. For increased contribution in the 1990's, however, most of these technologies would require stepped up development to reduce cost and resolve cost and performance uncertainties that concern utility investors. One approach to accelerating development would be to focus Federal research and development efforts on those technologies; in particular photovoltaics solar thermal parabolic dishes, and advanced small geothermal designs.

There are other approaches, however, which can supplement Federal efforts in technology development. Increased availability of natural gas coupled with supportive regulatory treatment of and tax incentives for cogeneration and small power production have led to considerably increased activity in non-utility generation in some regions, particularly those of highest load growth and fuel cost (the West and Southwest). The reemergence of non-utility power production as a growing industry in America is providing and can continue to provide an important test bed for some of these new generating technologies. For example, our analysis shows that the Renewable Energy Tax Credit (RTC) coupled with recovery of full utility avoided costs (PURPA) by non-utility power producers have both been crucial in the initial commerical development and deployment of wind and solar power generating technologies. In particular, with declining direct Federal support for renewable technology development, the RTC has supported development of speculative designs as well as commercial application of mature designs.

The future of non-utility applications of new generating technologies, however, is closely tied to future trends in avoided cost (and other provisions established by PURPA), Federal tax policy, and fuel availability and cost. Without continued favorable tax treatment, development of much of the domestic renewable power technology industry may be delayed significantly. In particular, without existing tax incentives, many of the generally small firms involved in development projects will lose access to existing sources of capital. Even large, adequately capitalized firms may lose their distribution networks, leaving the industry struggling to survive.

Another factor that is likely influence the rate of deployment of new generating technologies in non-utility applications is the evolving relationship between utilities and non-utility power producers as they interconnect with the utility grid. In particular, non-utility generators are likely to face different and sometimes conflicting interconnection equipment standards well into the 1990's. While most of the technical issues regarding interconnection have been resolved, application to specific utility circumstances is still an important area of uncertainty. As a result, these differences may hamper both the rate of deployment of non-utility generation as well as the standardized manufacture (to reduce cost) of interconnection equipment.

CONCLUSIONS

If increased contribution to U.S. electric power generation of the technologies we have considered is desired in the 1990's, we feel that while the current rate of development for some of these technologies is adequate, accelerated research, development and, particularly, demonstration for others would be required. For larger scale technologies in utility applications, cooperative industry-government demonstration efforts managed by the utilities have a very good track record. The current AFBC, IGCC, and geothermal demonstrations are good examples;

similar projects would be required for fuel cells, CAES, advanced battery technologies, and central receiver solar thermal power plants.

Successful technical demonstration alone, however, may not be sufficient to ensure timely application of these technologies. The lead times of early commercial units must also be shortened. In the course of demonstration projects, steps to increase the familiarity of a wide range of utilities as well as regulators with the technologies would help shorten the lead times of these early units by reducing regulatory delays.

Both technical development and early commercial applications of many smaller scale technologies have been aided considerably to date by Federal investment incentives for non-utility power producers such as favorable tax treatment and PURPA. Continuation of such measures could assist accelerated contribution of these technologies in the 1990's, but, again, such efforts alone are probably not sufficient to ensure timely development and application. Additional steps to improve regulatory familiarity and hasten resolution of interconnection issues are needed as well.

With the efforts outlined above, many of the technologies we have considered could be available to contribute to a diverse array of electric power generating technologies in the 1990's, capable of flexibly meeting future load growth and increasing clean and efficient utilization of domestic energy resources.

Mr. **Fuqua**. Thank you very much, Dr. Blair.

Commissioner, we're very pleased to have you and hear from you at this time.

STATEMENT OF STEPHEN WIEL, COMMISSIONER, PUBLIC SERVICE COMMISSION OF NEVADA AND MEMBER, COMMITTEE ON ENERGY CONSERVATION, NATIONAL ASSOCIATION OF REGULATORY UTILITY COMMISSIONERS

Mr. **Wiel**. Mr. Chairman, members of the subcommittee, thank you very much for the opportunity to speak today. I'm Steve Wiel, a Nevada Public Service Commissioner and a member of the Committee on Energy Conservation of the National Association of Regulatory Utility Commissioners. I'm here today speaking on behalf of NARUC and I have with me, to answer any questions you have about NARUC, Paul Rogers, who is the Associations Executive Director, sitting behind me and also Jill Rowe and Sam Swanson.

My comments address the efficient development and use of electric energy with a purpose of making the recommendation for inclusion of funds in the Department of Energy budget for moneys for appropriate data and analytical tools to help with the development of least cost electrical energy.

First I'd like to expand on the comments that Dr. Blair made in his testimony, regarding the changing environment for investors. It's true what he said; times are different as a result of the increasing costs for conventional plants, as a result of increasing fuel costs, and as a result of increasing benefits from the development of technology of alternatives and I can best demonstrate that to you by an example from Nevada. In 1975 in Nevada, it cost $250 per kilowatt to build a new base generating power plant and in 1985, 10 years later, it now costs $1,700 to build a baseload generating plant. In the meantime, the typical bill, the revenues generated from that investment, has gone from $19 in 1975 to $42 in 1978. So in other words there has been a 6.8- fold increase in the cost of the investment and only a 2.2-fold increase in the revenues generated, with the increase in operating costs, the pay-back period on that investment to the utility company has increased from 13 years to 40 years.

In the same 10 years, alternatives have developed so that today Nevada's utility companies can invest—well, Nevada Power Co., at any rate, can invest— $7 in an attic insulation program and avoid 1 kilowatt of peak demand. In other words, avoid the need to spend $1,700 and that $7 investment will return to the utility company $40 a year in avoided cost of fuel to have to run the powerplant. The economics have changed dramatically, yet, for various reasons—which I'm happy to elaborate on later, if you'd like, or otherwise submit additional comments on—for various reasons, the utility company executives have not responded. Part of that reason is human nature. Part of that reason is the relationship between electric utility companies and their commissioners, and that's where we see that the National Association of Regulatory Utility Commissioners has a role. But before I describe that role, let me tell you about some success that we've had in Nevada in changing the relationship between the electric companies and their commission and, therefore, in their investment habits.

In 1983, Nevada passed the Resource Planning Act and that act requires resource plans every 2 years from its major electric utility companies. There are two of them, and plans were submitted this past July. They've been approved by the commission and they call for 20-year growth plans. Just looking at the first 5 years of those plans, the utilities have promised to attend to 19 percent of their forecast growth for electricity by avoiding that demand through conservation of load management. They've done this under the act and increased rates by two-tenths to four-tenths percent and the way rates are increasing in general in Nevada, that's practically nothing. In fact, Nevada, as you know, is the second fastest growing State in the Nation. It has virtually no excess capacity and attending to future growth is an important point. Our success mainly comes from requiring, "adequate and equal consideration be given to all conservation measures and supply measures." Essentially what we do is we tell the utility company, "Here's some planning money, you get it back up front, no uncertainty about that. You will have your implementation money back, at least as favorably as if you had invested it in a new plant and you are responsible for your own planning. We're simply going to look over your shoulder." The result is a plan by Sierra Pacific and another plan by Nevada Power Co., which balances conservation, cogeneration, geothermal development, and coal-fired powerplants in their 20-year forecast. The important point is there is an integration of the demand side measures, as we call them, conservation and load management, with the supplyside measures. That's a unique part of our program and it's very, very successful. We're quite confident that we have found a least-cost solution.

I have taken the liberty of extrapolating Nevada's experience nationwide just to show what kind of an impact it could have. And of course, there's some significant assumptions here, but if we achieved the 19-percent reduction in 5 years that we forecast and if other States could do the same thing and if this is in addition to the existing conservation load managment programs that exist, the national savings in 5 years would be 21 gigawatts or the equivalent of 18 Seabrook-1 reactors with an annual fuel cost savings of $2.2 billion avoided. And we, in Nevada, think that we have done something special and that it's worthwhile for others in the country to do.

And being on the committee of the National Association of Regulatory Utility Commissioners, I've had an opportunity to talk to others about it and NARUC is in fact moving in this direction in a policy sense. First of all, at this last annual meeting it raised its ad hoc committee, the subcommittee on energy conservation, to a full committee, and passed three resolutions—three they're policy resolutions. One of them is attached to my testimony. Essentially they call for development of least-cost system plans as a policy by the Federal Government, also by State governments and also by utility commissioners across the country.

In order for NARUC to achieve this, three things are needed. First, as we see it, there must be a national data base. The utility—individual utilities and even individual commissions simply can't go out and reinvent the wheel and compile all the information that's necessary for the unique situations that exist for the utilities in each State.

Second of all, some standardization of the analytical tools are required. These tools are basically available. I'm talking about analyses to determine the benefit costs of conservation measures, of supplyside measures, such as geothermal, cogeneration, but most importantly, how to integrate them to find for each utility what is best because, for example, if you're saving lightbulbs in one utility company, the number of lightbulbs that might be on at the time of worst need, is different. The avoided cost of fuel is different and so each utility company needs the analytical base so they can do their own analysis.

And finally, NARUC needs to take this technology and disseminate it to the commissioners, so that the commissioners throughout the country can essentially change their ways, let the utility companies know what the new rules are and—and simply accelerate the process of getting on with least cost planning. And to this end NARUC makes the following recommendation: That a line item be identified in the U.S. Department of Energy fiscal year 1986 budget which includes funds earmarked for the National Association of Regulatory Utility Commissioners to support their efforts to promote least cost system planning for major gas and electricity utilities. These funds would be used by NARUC to—under contract to some national laboratory, such as Lawrence Berkeley Lab, perhaps there are others or our own research arm, the National Regulatory Research Institute. And only a small portion of the funds would be spent by NARUC for the dissemination. I thank you for the opportunity and would be happy to answer questions or submit any additional information which you would like.

[The prepared statement of Mr. Wiel follows:]

STATEMENT OF

STEPHEN WIEL

Commissioner, Public Service Commission of Nevada
and
Member, Committee on Energy Conservation
National Association of Regulatory Utility Commissioners

BEFORE THE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY

On behalf of the State of Nevada's Public Service Commission and the National Association of Regulatory Utility Commissioners, I thank the subcommittee for the opportunity to testify on an issue of significant concern - the efficient development and use of electric power.

I am Stephen Wiel, a Nevada Public Service Commissioner and a member of the National Association of Regulatory Utility Commissioners (N.A.R.U.C.). The Association is a quasi-governmental nonprofit organization composed of governmental agencies engaged in the regulation of public utilities and carriers. The Association has been used by the Federal Government for 96 years as a key instrument to maintain and strengthen Federal-State cooperation in this regulation. I am a member of N.A.R.U.C.'s Energy Conservation Committee and am speaking today on behalf of the Association.

N.A.R.U.C. believes that it can help satisfy this country's future demand for electricity in the most efficient way possible. Utility companies are not currently choosing the wisest investment for satisfying the nation's increasing appetite for electricity. They should be and inclusion of funds in a line item in the U.S. Department of Energy's appropriation for development of appropriate data and analytical tools would assist N.A.R.U.C. to see that they do.

1. UTILITY COMPANIES, IN GENERAL, ARE CURRENTLY INVESTING UNECONOMICALLY

The traditional investment by electric utilities in large oil, gas, coal or nuclear power plants, in many cases, no longer provides least-cost electricity. There are three primary reasons for this. First, the steady stream of improvements in power plant productivity over most of the twentieth century ended in the late 1960's. The long term trend of new power plants producing cheaper electricity than older plants was over and the cost of new electricity began to rise. Second, the cost of fossil fuels rose dramatically in the 1970's, further escalating the price of electricity. Third, great improvements have been achieved over the past decade in developing conservation and load management technology and alternative supply technology. The costs of these new technologies have been decreasing sharply.

The result can be shown by the following example: In 1975 when a base electric plant cost $250 per kilowatt to build, a typical family in Nevada paid $19 for the 500 kilowatt hours it used each month. In 1985, a base electric plant costs $1,700 per kilowatt to build and that same typical family pays $42 for the 480 kilowatt hours it now uses each month. In ten years, the investment in providing baseload electricity rose 6.8 times while the resulting gross revenue generated by that investment rose only 2.2 times. Operating costs also rose so that the payback to the power company for adding base capacity to serve typical Nevada residents rose in that ten year period from 13 years to 40 years. Meanwhile, alternatives became increasingly available at decreasing prices. In 1985, the same power company can insulate its existing customers' attics to reduce peak demand for an investment of $7 per kilowatt. As a result of that $7 investment, the company will save $40 per year of fuel costs no longer required to supply 1,340 kWh of electricity. This attic insulation program is one example from a myriad of conservation measures, load management techniques, geothermal resources, cogeneration arrangements and other sources of electricity which now compete favorably with traditional sources of electric power. Alan Meier, Janice Wright and A. H. Rosenfeld show the extent of cost effective alternatives in their book Supply Energy through Greater Efficiency. Similar economics to those in Nevada prevail throughout the United States.

Despite the change in technology, many electric utility executives still have a strong tendency to continue investing in traditional supply resources. There are many explanations - human nature, institutional lethargy, and rate-base regulation to name a few. The fact remains that current investments in new electrical generation are frequently not cost effective and are causing waste of this nations energy resources.

2. SIGNIFICANT SAVINGS COULD RESULT FROM LEAST-COST INVESTMENT BY UTILITY COMPANIES

In 1983, Nevada passed the Utilities Resource Planning Act to help ensure the least-cost development of electricity and speed up the utilities' response to the changing technology. The results are promising. In their first Resource Plans, Nevada's two major electric companies have committed to use conservation and load management to provide for at least 98 megawatts of their combined 512 megawatts growth expected over the next five years. This is 19% of the forecast demand. Most importantly, both Resource Plans show a hesitancy in commitment to new generating plants. This hesitancy appears to be a deviation from tradition. Some people in Nevada believe that the conservation and load management programs will be so successful that no new generating plants will be built in Nevada in the foreseeable future. They expect this despite the fact that Nevada is the second fastest growing state in the nation and, unlike many states, currently has no excess generating capacity. Others in Nevada are not so optimistic. Either way, energy conservation and load management have become institutionalized in Nevada in a way which will surely result in least-cost electricity in the future.

The cost of this planning in Nevada appears to be well worth the investment. Nevada's two large electric companies together spent $1.09 million building their planning capabilities in the first year of the program. This has added 0.012¢, two tenths of one percent, to each kilowatt hour of electricity sold by Nevada Power Company and 0.036¢, four tenths of one percent, to each kilowatt hour sold by Sierra Pacific Power Company. The continuing cost is expected to stabilize in the 0.02 to 0.04¢/kWh range.

While a few other states have programs similar to Nevada's Resource Planning Program and several have programs containing elements of it, Nevada's is unique in its comprehensiveness and its mandate. The Nevada law requires "adequate and equal consideration be given to all conservation measures and supply measures." The resulting analysis requires that the least-cost path be found for satisfying the State's future electricity needs. As a result, Nevada electric companies have so far chosen a mix of conservation, cogeneration, geothermal development and new coal fired power plants. The resource planning process makes no prejudgments about which technology. It simply ensures that investments will be selected which best satisfy a given utility's needs at any given time.

At the risk of oversimplification, I have calculated the potential magnitude of the impact of Nevada's experience applied nationwide. If Nevada achieves at least its 19% peak demand reduction over the next five years and if other states could attain the same and if this reduction is considered to be in addition to existing conservation and load management programs, then the nationwide avoided generating capacity over five years would be 21 gigawatts, the equivalent of 18 Seabrook-1 1,150 MW power plants. In the process, $2.2 billion in fuel cost for generating 74,000 gigawatt hours of electricity would be avoided. Amory Lovins, in a paper titled "Saving Gigabucks with Negawatts" which he presented at N.A.R.U.C.'s 96th annual Convention last November argued that the total potential savings from the development of least cost electricity is far greater than that shown in my simple example.

3. N.A.R.U.C. CAN HELP NUDGE THE UTILITY COMPANIES

The National Association of Regulatory Utility Commissioners has been taking an increasingly active interest in energy conservation and resource planning over the past few years. At its annual convention last November, N.A.R.U.C. elevated its Ad Hoc Committee on Energy Conservation to a full standing committee and passed three policy resolutions on the subject. These three resolutions request the U.S. government, state governments and state and federal regulatory commissioners each to support the development of least cost system plans for major gas and electric utilities. The three resolutions are similar and the one addressing U.S. Government support is attached here for your review.

I believe that direction and support by the individual state commissions is the best way to influence the investment behavior of the utilities. Many experiences in my life have reinforced my belief in the old saw, "You can lead a horse to water but you can't make it drink." Since becoming a Commissioner, I have encountered nothing as stubborn as a reluctant utility company president. In resource planning, we on Nevada's Public Service Commission have overcome the utilities' reluctance by strong positive support; we approve their spending and they do their own planning.

N.A.R.U.C. is in a position to encourage and support commissioners throughout the U.S. in developing similar least-cost resource planning. Three things are needed in support of such an effort:

1. A national data base on the cost effectiveness of energy conservation programs, load management programs, cogeneration opportunities and renewable resource power plants.
2. Accepted analytical tools for evaluating demand side and supply side programs and for integrating these to find least-cost solutions to future electric needs.
3. Dissemination to commissions of the information and basic tools needed for developing least cost system planning programs.

N.A.R.U.C. is proceeding along this path.

4. N.A.R.U.C.'S RECOMMENDATION

Federal support would greatly enhance N.A.R.U.C.'s efforts along this path. Research and development funds are needed to develop a data base that conclusively establishes the benefits of least cost planning in all regions of the country. Toward this end, N.A.R.U.C. would use funds available for this purpose to contract with some nationally respected and capable research organization such as Lawrence Berkeley Laboratories (LBL) to accomplish this task. Likewise, an organization like LBL would be hired to develop appropriate analytical methodology acceptable to the utility companies. Dissemination of the information could be accomplished by N.A.R.U.C. directly, possibly in conjunction with its research arm, the National Regulatory Research Institute (N.R.R.I.).

We are disappointed to find no line item in the U.S. Department of Energy's FY 1986 budget request that supports an activity as clearly beneficial as that which we have described. Thus, we make the following recommendation:

> N.A.R.U.C. recommends that a line item be identified in the U.S. Department of Energy FY 1986 budget which includes funds earmarked for the National Association of Regulatory Utility Commissioners to support their efforts to promote least cost system planning for major gas and electric utilities.

Thank you for the opportunity for me to present N.A.R.U.C.'s views.

NARUC Convention Resolution No. 5

Resolution Supporting the Adoption of National Energy Goals

WHEREAS, There are national imperatives which require renewed vigor in the development and implementation of national energy policy; and

WHEREAS, The Nation continues to be dependent upon petroleum and other non-renewable resources as energy sources; and

WHEREAS, Existing national and international energy policies and conditions do not preclude the recurrence of serious problems arising from this dependence; and

WHEREAS, The increase in energy prices has a major adverse impact on the Nation's citizens and its economy; and

WHEREAS, Conventional sources of energy are subject to constraints involving supply, transportation, cost, environmental, health and safety considerations; and

WHEREAS, The Nation must devise strategies by which to address these problems including, but not limited to strategies to assure adequate, efficient, reliable energy supply and to avoid unnecessary and wasteful consumption; and

WHEREAS, Cost effective energy conservation measures can address such issues appropriately; now, therefore, be it

RESOLVED, That the National Association of Regulatory Utility Commissioners, assembled in its Ninety-sixth Annual Convention in Los Angeles, California, adopts the following goals and urges the government of the United States to find it in the interest of the nation to:

I. Assure adequate and reliable energy supply by using resources in the most efficient manner, by replacing energy resources vulnerable to interruption due to circumstance beyond the nation's control with those less vulnerable, and by encouraging the development and utilization of renewable resources;

II. Define conservation in terms of both avoidance of unnecessary and wasteful consumption and in terms of economic efficiency;

III. Promote conservation by encouraging consultative participation of states, local governments, consumers, energy companies, and the public at large in developing, implementing and updating plans and programs related to energy resource conservation and development;

IV. Improve utility conservation programs by raising consumer awareness to the benefits of conservation, by increasing consumer participation and by requiring utilities to develop programs to achieve implementation of audit recommendations;

V. Encourage development of least cost system plans for major gas and electric utilities in order to meet energy needs over the coming decades, which plans shall include the following: (1) conservation, (2) renewable resources, (3) use of waste heat or high fuel conversion efficiency and (4) all other resources;

VI. Concentrate additional federal efforts on strengthening the Department of Energy's ability to gather data, provide coordination and provide assistance to states and the public; on establishing national appliance efficiency standards; on requiring increased thermal efficiency in buildings; and on establishing energy efficiency in transportation; and

VII. Provide for the essential energy needs of the disadvantaged by providing utility incentives for the development of conservation and audit services, by providing increased permanent weatherization services for low income households, and by eliminating financial barriers to conservation improvements for the needy through loan or grant programs.

Sponsored by the Ad Hoc Committee on Energy Conservation

Mr. **Fuqua**. Thank you very much, Commissioner.

Mr. Sklar, we're glad to have you here this morning and we appreciate hearing from you.

STATEMENT OF SCOTT SKLAR, DIRECTOR OF GOVERNMENT RELATIONS, SOLAR ENERGY INDUSTRIES ASSOCIATION, WASHINGTON, DC; ACCOMPANIED BY CARLO LAPORTA, DIRECTOR OF RESEARCH AND TECHNOLOGIES

Mr. **Sklar**. Thank you, Mr. Chairman. I came and our director of research, Carlo Laporta, is to my right. I just want to outline the four points that we so are—that was essential for an effective energy program. Obviously a maintaining of the Federal Research Program in DOE, that transfer both of basic and applied research to the private sector is, I think, of a great importance to us. We are concerned, obviously, of the 17-percent cut. We think the budget is barebones minimum now that will fall below $200 million and to point out to you I think that just any more cuts in this regard, in this teeny part of DOE, there's some question whether it's worth it or not and I want to make that clear.

The second point is the national export policy. As you know, Public Law 98-370 created a Federal interagency secretarial working group to help form a national renewable energy export policy to coordinate activities. Secretary Hodel was very committed to working that through. He is now gone and I do hope that this committee will take an active role in assuring that this laudable goal is reached.

The third is the maintenance of DOE's existing information programs. The solar industry is a very, very small industry. Although our sales have topped $1 billion now, we're starting to get into the mainstream. The DOE information programs are ones that are very small investments to help us maintain a competitive edge. The Energy Information Administration [EIA] data collection is essential to us. We are concerned that that may be gutted and that will not help us maintain the kind of data we need to compete effectively. The Consumer Information Program, CAREIRS, is zeroed out and the technical assistance service, NATAS, should be funded at least at its $1.5 million level to do the job. Again, a point when you get so low it's almost not worth having these things.

The final point that I have in terms of energy policy and the point that this industry has been looking at is, obviously, the extension of residential and commercial tax credits. There is a lot of talk today about dreams not realized. This is effectively one such policy that may get those dreams into the real world and that is getting market incentives for this industry. The solar industry, I think, has taken a pragmatic view in the recent bill that Mr. Fowler introduced, H.R. 1272, that has the support of the senior Ways and Means Committee members. The bipartisanship is the fact is that we're recommending a phaseout over 5 years and we still think that we can compete, after 1990, against the conventional energy industries that are subsidized on the average of $3.5 billion a year. We're doing this phaseout because we think it's acceptable on the Hill. We can compete and that the four points I mentioned is part of an overall and effective energy program.

I just have a few comments to make on the actual DOE budget. One is that former Secretary Hodel asserted his desire to upgrade SERI to national lab status. We think over the next few years that that ought to be realized. We need a focal point of research. Our international competitors and their governments have similar kinds of activities and we need that.

Second, in the research budget, specifically, I believe that there is a bias of those budget decisionmakers in DOE and OMB against high temperature solar thermal. We are recommending $10 million more. We hope that no, we're not stepping back from a commitment to develop these technologies. The cost of the DOE program, the solar thermal technologies have achieved the highest net conversion efficiency yet recorded, 29 percent for conversion of sunlight to electricity.

In the Photovoltaics Program and in particularly SMUD, we are not happy with the $4 per watt that was recommended here. We originally agreed to that because we thought their procurement request would be based on 24 megawatts of mixed purchase energy. That is not what was done and part of the problems we have in the solar energy, and I'm sure you've heard this before, is mixed messages. If somebody makes a promise to you, either keep the promise or work with the industry to work out an effective solution and we're hoping that your staff and maybe DOE and we could talk about that a little more.

Finally, and I think most importantly, the industry has been working in many other forms—ways in the Federal Government. One is through the procurement process, so that the Department of Defense may rule on this amendment requiring purchase of renewable energy devices, when cost effective. Under Secretary Pat Collins has taken a very positive role in getting that interaction with DOD to develop those kind of procedures. We've met with the Air Force engineers, chief engineers out in New Mexico, at a conference, to see what they can do and they're still sort of skeptical and because the taxpayer pays the utility bill on Federal buildings, we hope that DOE will maintain that role and I just want to thank you and the committee for your strong support of our programs. Thank you, sir.

[The prepared statement of Mr. Sklar follows:]

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TESTIMONY

by

Scott Sklar
Director of Government Relations
SOLAR ENERGY INDUSTRIES ASSOCIATION

before

SUBCOMMITTEE ON ENERGY DEVELOPMENT & APPLICATIONS
HOUSE SCIENCE AND TECHNOLOGY COMMITTEE

MARCH 7, 1985

INTRODUCTION

Energy development must be viewed as part of an overall national energy policy which encourages a diversity of energy resources and technologies which are domestically produced, environmentally acceptable, and most efficiently utilizable.

A national energy policy must incorporate certain key criteria in order to be successful:

1) Development of research programs that effectively transfer basic research to those performing applied research, and then transfering applied research in a useful way to the private sector.
2) Development of a national export policy which will directly create the tools for the American solar industry to compete effectively against our foreign competitors.
3) Development and maintainance of existing information programs: that transfer current technical information to the research community, that transfer information to the private sector, and that transfer basic information to the consumer and general public on solar and renewable forms of energy so that they will make informed purchasing decisions.

4) Extension of market incentives, specifically residential and commercial tax credits, which will expand the market for solar technologies to such a point that the industry will not need further tax incentives past 1990, even though they will compete against heavily subsidized conventional energy industries.

These components outlined above are essential in developing a sound and effective national energy program. I will discuss the industries' position on these points in more detail.

BUDGET PRIORITIES

The Administration proposes to cut the U.S. Department of Energy renewable budget from $211.8 million to $175.6 million, (a 17% cut), while increasing the civilian nuclear budget by 6.3% from $1.704 billion to $1.813 billion. In this time of increasing federal deficits, all industries including the solar energy industry are willing to accept budget cuts as long as they are equitable. How in good conscience can the U.S. Congress slash the already decimated solar and renewable energy research budget when they are increasing the civilian nuclear energy budget by over $100 million? The solar budget over the last five years has been cut from over $750 million to less than $200 million. Frankly, if the solar and renewable energy budget gets cut much below $200 million, I question the worth of federal support and actual federal interest in maintaining a national renewable energy industry that has just begun to out distance the nuclear power industry in overall energy produced.

The solar and renewable energy budget must incorporate the following points, if the U.S. Department of Energy program will be at all responsive and supportive of the solar industry and the general public:

1). With more limited resources, the U.S. Department of Energy research budget can be reordered to better meet industries' needs. This reprioritizing must be done to insure a fair and reasoned energy research program.

2) The U.S. Department of Energy must retain its authority and appropriations for its international programs so that the U.S. solar industry will have the support and guidance to compete in international markets. The U.S. is already falling behind and how ironic it would be that the solar technologies developed in the United States through considerable tax payer support will eventually be imported from our industrial competitors who have supported their solar industries more effectively than the U.S.

3) The U.S. Department of Energy must retain its consumer and technical assistance services so that the American public and industry can obtain the information in a timely manner. While utility companies offer oil, natural gas, and electric information, purchasers of solar equipment should not be discouraged from

obtaining a technology that uses domestic resources. The Administration's request to lower the funding of these information programs is not penny wise and is a low cost investment to promote solar energy.

4) The U.S. Department of Energy must retain a management system that insures efficiency but retains a strong programmatic oversight. I laud former Secretary Don Hodel, Undersecretary Pat Collins, Deputy Assistant Secretary Bob San Martin and his staff, for their support and commitment to carry out the solar and renewable energy programs in compliance with Congressional directives. As a result of the departure of Secretary Donald Hodel, who had a strong background in energy issues, I would like to urge this Committee to direct that all the management positions in the solar programs, i.e., that the Assistant Secretary for Solar, be filled as required by law.

5) The U.S. solar industry will not endorse any cuts in our programs while other energy programs are increased. The Solar Energy Industries Association strongly urges the members of this Subcommittee to endorse, co-sponsor, and actively work for passage of the extension of the solar energy residential and commercial tax credits. Congressman Wyche Fowler and 37 of his colleagues have introduced H.R. 1272 which scales down the current 40 percent residential solar

credits by five percent per year till they reach 15% by 1990, and extends the business credit at the 15% level while enhancing the business credit for high temperature solar thermal and photovoltaics at the 25% level through 1990 with a two year affirmative commitment rule. The Joint Committee on taxation has made a preliminary revenue estimate of $950 million of revenue loss spread over five years. This legislation requires that solar collectors be certified by existing certification entities in order to qualify for the credits except for self-built systems. In addition, the current $10,000 expenditure limit has been lowered to $6,000 for domestic hot water systems as a way to limit potential tax loss for solar hot water technologies which amount to over 95% of all solar systems for which the credit is claimed. This legislation slowly weans the solar industry off the tax credits without causing "market shock" and we believe makes us the first industry to offer to phaseout our credit even though our competing conventional energy industries--petroleum, nuclear and coal--receive over $3.5 billion worth of tax incentives per year according to the Joint Commmittee on Taxation.

BUDGET OVERVIEW

In regard to specific funding priorities within the solar research budget in the U.S. Department of Energy, and I am specifically referring to the technologies which the Solar Energy Industries Association directly represents--solar heating & cooling, high temperature solar thermal, and photovoltaics. The budget needs to insure that the investment the taxpayer has already invested in solar energy research and development is fully realized.

I. SERI

The United States must maintain its premier solar energy research facility based in Colorado, the Solar Energy Research Institute (SERI). Former Secretary of Energy Hodel asserted his desire to upgrade SERI to national lab status. SERI should be encouraged to mature and improve to achieve such a prestigious status. Not only should this upgrade be accomplished within the next few years, but this Subcommittee should insure that the basic research facility for solar energy be maintained, encouraged, and broadened so that a research focal point exists for the research community and the private sector. Ties between SERI and the private sector will thus be strengthened.

II. RESEARCH

The high temperature solar thermal budget currently at $35.2, million is now recommended to be funded at $28.4 million. SEIA's Solar Thermal Division has contacted the U.S. Department of Energy requesting a budget of $38.5 million. I have outlined their budget request below:

SEIA SOLAR THERMAL POWER DIVISION
FY 86 TECHNOLOGY BUDGET RECOMMENDATIONS
(millions of dollars)

A. RESEARCH $11.0
  1. EXPLORATORY
    a) Materials
    b) Innovative Concepts
    c) University Thermal Research
  2. SUPPORTING
    a) Innovative Concentrators
    b) Materials
    c) Storage
    d) Controls

B. CENTRAL RECEIVER TECHNOLOGY 13.5
    a) C.R.T.F. Operation
    b) Solar 1 Operation
    c) Automated Operations at Solar 1/C.R.T.F.
    d) Solar 1 Retrofit

C. DISTRIBUTED RECEIVER TECHNOLOGY	13.0
1. POINT FOCUS	
a) Test facilities	
b) Thermal Transport	
c) Heat Engine Adaptation	
d) Advanced Concentrator	
2. LINE FOCUS	
a) Test Facilities	
b) IPH Data Acquisition and Support	
D. PLANNING AND PROGRAM SUPPORT	1.0
TOTAL	$38.5

The Solar Energy Industries Association has a real concern that the U.S. Department of Energy, Office of Management and the Budget, and whoever else has been involved in the budget process, are stepping back from a commitment to develop high temperature solar thermal technologies which can produce industrial grade process heat and thermal heat to produce electricity. Level funding is essential for these technologies to eventually become competitive in the marketplace. Because of the DOE program, solar thermal technologies have achieved the highest net conversion efficiency yet recorded (29%) of sunlight to electricity. Solar thermal systems can provide thermal and electric energy at any scale, completely compatable with conventional energy systems, they offer unique advantages for high temperature heat production without contaimination, in the production of advanced fuels and chemicals. We have only just begun to explore the long term potential of these technologies, and further cuts in the program would be a serious setback. At present, we are at a critical stage in the development of the high temperature industry, because once these scaled-up demonstrations show they can operate effectively as indicated by DOE's research program, the utility companies will then be in a position to utilize this technology on a greater scale.

To maintain the United States' international leadership position in international testing. All photovoltaic modules to date have been tested for free at JPL Laboratories. Although they are tested, they are not certified according to any international testing criteria. The solar heating and cooling industry has created the Solar Rating and Certification Corporation (SRCC) which has been extremely effective in developing test procedures, coordinating testings, and disseminating rating information. Whether SRCC should be broadened to enter the testing and rating of photovoltaic modules or some other approach be developed, SIEA's PV Division encourages some discussion in this area.

Although research for research sake is useful and needed to develop long term solutions, I would like to call the Subcommittee's attention to the lack of a separate program element to assist the private sector in the solar manufacturing process. Such assistance would be vital for the American industry to compete against our international competitors. The applied research component need not be a large fiscal commitment, but at least we ought to have information through a careful assessment on US manufacturing capability vis-a-vis other industrialized nations who are actively involved in solar exporting. However, if the DOE budget is not equalized in regard to high temperature solar thermal development, the taxpayer investment in this promising technology will be for naught. Let's not waste years of development with some important milestones reached through the DOE program effort. SEIA urges the committee to maintain its commitment to a solar thermal program which is geared towards success.

The funding for photovoltaics research is down from $56.6 million to $44.8 million. The $44 million is the minimum base that the photovoltaics program can work effectively. One problem SEIA has noticed is that no funding has been included for the San Diego Municipal Utility Demonstration (SMUD), and the three residential experiment stations. Funds appropriated last year have not been commited to carry these projects out. In regard to SMUD, the bids were higher than the $4 per watt.

The industry needs appropriate funding to get the price down. The procurement request which we thought would be based on a 24 MW mixed purchase was not offered. And as a result, the industry offer was higher than anticipated. I urge this subcommittee to arrange a meeting between the appropriate individuals at SMUD, the U.S. Department of Energy, and the Solar Energy Industries Association, to make sure appropriated monies are spent and that consistant policies are followed concerning this project and the three residential experiment stations. Many solar companies have the technology and resources to carry out the project goals successfully. We need to get this program moving on course as soon as possible.

Funding for Solar Energy Building Systems is proposed to be kept at level funding. SEIA believes this program has been managed exceedingly well and there has been an attempt to secure industry input. Clearly, from the active solar heating and cooling point-of-view, tax credits are of ultimate importance. However, this program must be kept if the U.S. Congress does not support the tax credit extension efforts. However this program needs to look into systems integration--how day-lighting, conservation, passive and active solar application all interrelate. In addition, greater attention needs to be given to multifamily and commercial structures and obtain cost and performance data. To accomplish these additional tasks, this program needs to be expanded.

III. INFORMATION

The solar indsutry needs the federal support for information dissemination because the solar industry is a potpourri of mostly small selling businesses a broad range of technologies. The DOE sponsored hotline, Conservation and Renewable Energy Information Referral Service (CARIERS), must be continued as a way to refer the hundreds of thousands of consumers to the most approrpiate source of information as a way to stimulate purchases.

Another program that SEIA supports is the DOE National Appropriate Technology Assistance Service, a technical assistance program for renewable energy and energy conservation. This toll-free line to the public offering tailored technical assistance has been in operation since May 1, 1984. It has reached approximately 8,700 users already, above their projected operating level, responding with in-depth, site-specific assistance. In addition to the excellent program that the base NATAS service offers, broadening of the NATAS scope to include new publications, monitoring and training of DOE personnel, seems worthwhile.

The base cost for operating this NATAS toll-free technical service is $1.5 million. SEIA strongly support the position that the Committee retain at least this base as a minimum authorization level. The broader scope for NATAS will cost an additional $1 million, which would raise the authorization needs to $2.5 million. I urge the Committee to consider the worthwhileness of the how-to publications and monitoring such an authorization would cover, but to definitely authorize a minimum of $1.5 million for the base NATAS program.

IV. EXPORTS

P.L. 98-370 was signed into law last year to create a national renewable energy export policy through the creation of a Secretarial-level interagency coordination group. The first meeting was held in January 1985. SEIA's concern is that the Congressional reporting deadlines are met, and that in fact, the interagency coordination actually takes place and becomes systematized. The Congress must oversee this process so that the cooperation remains high and that the ultimate goal be met. After tax credits, this coordination program may be the single most important incentive to the solar industry, particularly to the photovoltaics industry segment, than any other incentive.

V. PROCUREMENT

The U.S. Department of Energy has taken a lead role in assisting the U.S. Department of Defense in complying with the Mavroules Amendment which required the DOD to procure renewable energy devices when cost effective. SEIA held a briefing of senior procurement officers in DOD this past summer. We were advised that the senior procurement officers support solar energy but the solar industry must make its case to the local procurement officers who develop the local procurements and have the ultimate control over the procurement process. A SEIA representative was included in the Air Force Energy Working Group meeting held in January in New Mexico. The base engineers who attended this briefing seemed skeptical about the potential use of solar. Therefore, the industry needs greater DOE support and probably some funding to carry out a large number of briefing programs necessary to work our way into the DOD procurement market. DOD is a very large potential customer, and a customer that owns their buildings through its entire life and pays the total energy costs. It is in our national security and taxpayers' interests to incorporate solar usage in all federal buildings where efficient, and I hope that DOE will be encouraged to maintain a strong role in this regard. Undersecretary Pat Collins has been extremely effective in this area.

CONCLUSION

The proposed FY'86 U.S. Department of Energy Solar Budget is at its bare bones minimum. The Solar Energy Industries Association can live with the overall cuts if the other parts of the DOE budget sustain similar cuts, which is not currently the case.

Certain changes in the internal prioritization within the solar budget need to be made, particularly in the case of high temperature solar thermal and photovoltaics programs.

The interagency export group created by legislation in 1984 must be watch dogged so that the United States has a coordinated national renewable energy export policy so that we do not loose the potential multi-billion dollar international solar energy market.

The U.S. solar industry must have; continued market incentives, residential and commercial tax credits (which can be phased out over the next five years). Without these incentives the solar industries' sales will be cut by 50 percent and the industry will be all but crippled.

Finally , information and procurement programs and efforts must be continued if the market is to be expanded through an educated consumer. With multi-billion dollar trade deficits, programs promoting the use of domestic forms of energy which can be developed with minimal environmental impacts should be actively and aggressively encouraged.

Mr. FUQUA. Thank you very much and we appreciate your being here. We will have some questions for you submitted in writing to answer. Commissioner, we want to thank you for being here and what you're doing with your organization. I know in our own State they've been very very concerned about that and we appreciate what you're doing.

Mr. WIEL. Thank you very much.

Ms. SCHNEIDER. Mr. Chairman, may I also have the opportunity to include an opening statement in addition to some questions that I have for the witnesses?

Mr. FUQUA. Certainly and Ms. Schneider's statement will appear after my opening statement at the beginning of the record. Thank you very much and the hearing will adjourn, and we will have written questions for you. I apologize for the time constraints.

Mr. SKLAR. No problem. Last, but best.

[Whereupon, at 12 noon, the subcommittee recessed to reconvene at the call of the Chair.]

[Questions and answers for the record follow:]

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JOHN H. GIBBONS
DIRECTOR

June 11, 1985

The Honorable Don Fuqua
Chairman
Committee on Science and Technology
U.S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, DC 20515

Dear Mr. Chairman:

Thank you for your follow-up questions regarding OTA's testimony before the Subcommittee on Energy Development and Applications on March 5, 1985. Enclosed is our response to those questions. If you, any Member of the Subcommittee, or the Subcommittee staff have any additional questions or would like elaboration on our response we would be pleased to provide further information. In addition, many of the follow-up questions are discussed in more detail in our forthcoming assessment, New Electric Power Technologies: Problems and Prospects for the 1990's which is now undergoing final review with the Technology Assessment Board.

Thank you again for the opportunity to testify on this important issue before your Subcommittee.

Sincerely,

Peter D. Blair
Project Director

PDB/apl
enclosure

P. Blair 3/5/85 Testimony Questions

1. **Given the findings of your study, please comment on the level and mix of DOE's R&D activities in the FY 1986 proposed budget for the Renewable Energy Program. Are there areas that need either increased or lesser emphasis? Please explain.**

Since our study analyzes only electric generating technologies, my comments on the DOE budget are restricted to programs affecting those technologies. A fundamental finding of this study is that, at the current rate of development, most new generating technologies are not in a position to contribute substantially to new electricity supply nationwide in the 1990's. A variety of factors provide the rationale for this finding, many of which vary by technology including the time available to develop the technologies, i.e, to reduce cost, improve performance, and resolve cost and performance uncertainties, as well as the expected length of pre-construction and construction leadtimes associated with bringing these technologies on-line.

Under the economic conditions prior to the last decade affecting investment decisions in the electric power business, this finding might be of relatively little importance to the DOE research, development and demonstration agenda of supporting long term, high risk technologies. However, in the course of our analysis we also found that the environment within which utilities make new investments has changed markedly. In particular, flexibility in dealing with uncertainty in future load growth is now a fundamental consideration in analyzing new investments. If electricity demand grows at an average annual rate below 2.5 percent through the 1990's (current estimates range from 1 to 5 percent), the need for new generating capacity is likely to be relatively modest. Responses that include life extension and rehabilitation of existing generating facilities, increased power purchases, and construction of realizable amounts of conventional generation are likely to suffice. But if demand growth should accelerate, these options may not be enough; the experiences of the 1970's, however, have made utilities much more wary of the financial risk of guessing wrong and over-committing to traditional large central-station coal and nuclear plants. As a result it may be prudent to ensure the availability of an array of generating technologies that provide a utility with greater flexibility for meeting load requirements. Many of the technologies evaluated in our study offer, among other desirable characteristics, the potential for short lead times, small scale, and modular design that contribute to this flexibility.

Ensuring availability of these technologies in the 1990's would require combinations of cost reductions, performance improvements, and shortening of lead times for most of the technologies we analyzed in this assessment. The time between now and the 1990's is critical if these technologies are to be able to provide an insurance role in serving accelerated load growth in the 1990's, should it occur. If the technologies are not commercially available and accelerated load growth does appear, utilities may be forced to rely solely on conventional, short lead time technologies to serve this load (e.g., natural gas fired combustion turbines) and a "window of opportunity" to apply new technologies will be lost. Moreover, the domestic industry supporting these new technologies will begin to erode as this market opportunity vanishes.

If insurance against severe problems in meeting potential accelerated load growth in the 1990's is considered important, it suggests a shift in the DOE support of these technologies away from a long-term, high-risk policy to pursuit of more short-term commercialization objectives, at least for the next 5 years. This shift could include a refocussing of direct support for research, development and, in particular, demonstration activities as well as indirect efforts such as favorable tax treatment and other policy actions. For example, this might include increased direct support to parabolic dish solar thermal technologies and photovoltaics and heightened involvement in AFBC, IGCC, CAES and geothermal demonstration efforts to ensure application to a wide variety of electric utility circumstances. Indirect efforts could include extension of the renewable energy tax credits and loan guaranties for large demonstration projects.

2. **You have stated that, "Central Receivers . . . while showing long term promise are unlikely to be competitive with other power generation alternatives or have sufficient commercial demonstration experience to yield any significant contribution through the 1990's." With limited federal dollars, should central receiver R&D activities be focused toward the longer-term R&D or toward providing a larger system experiment that gives utilities some scale-up experience beyond that gained from Solar I at Barstow?**

In the case of the solar central receiver it is not clear that (1) some of the fundamental technical problems with the technologies have been resolved to a degree so as to ensure a successful commercial demonstration or (2) a scaled-up demonstration facility would be enough experience to stimulate significant commercial applications in the 1990's. Hence, to the extent that solar thermal technology can contribute substantially in the 1990's, as noted in our testimony, it is more likely to be with parabolic dish or solar trough technology -- not the central receiver. Therefore, while for many of the technologies we have considered a refocussing of Federal support for R&D could accelerate commercial viability in the 1990's, this course would be less productive for the central receiver.

3. **What is your judgement about the cost and performance potential of different solar thermal electric generating technologies DOE is currently supporting?**

The current DOE solar-thermal electric effort focuses on "processes and components," primarily aimed at the central receiver and parabolic trough technologies. Both technologies offer considerable cost and performance potential beyond the turn of the century. The parabolic dish technologies offer the most promise over the next 10-15 years, although with current uncertainty in cost and performance solar troughs may be competitive as well. Characteristics of some solar dish and trough designs indicate that they could be rapidly put in place in areas such as the Southwest. The cost of power generation using these designs in such regions could be very close to those of conventional alternatives. Some demonstration and subsidized commercial units already are operating. Full commercial application, however, will require further demonstrations of the technologies over extended periods of time; such demonstrations must be started no later than 1990 if the technologies are to be considered seriously by investors in the 1990's. The likelihood of such demonstrations, however, appears now to depend on the availability of some kind of subsidy. In particular, development of the technology to date has depended heavily on the Renewable Tax Credit.

Other solar thermal technologies, including central receivers and solar ponds, while showing long-term promise, are unlikely to be competitive with other electric generating alternatives or have sufficient commercial demonstration experience to yield any significant contribution through the 1990's. The central receiver, however, is of continuing interest to a some southwestern utilities in the long term because it offers a favorable combination of advantages including the potential for repowering applications, high efficiency and storage capabilities.

4. **One of the frequent criticisms of the Renewable Energy Tax Credit has been that it is being used to support poor technology. An often posed alternative, a production tax credit, would award benefits on "electricity produced" rather than "investment made." Would such a proposal be an improvement over the current system?**

If the objective is to maximize energy produced from renewable resources from current technology, then a Production Tax Credit (PTC) would likely be an improvement. Our analysis indicates, however, that the role of the renewable tax credit (RTC) in accelerating commercial development may have changed somewhat in the last several years. The original Federal policy was to provide direct research support to develop the technology and the RTC to accelerate commercial deployment. With decreased Federal research and development support, the RTC appears to be supporting research and development in the field; this might partially explain the wide variation in performance of wind projects in recent years. Hence, while tax benefits tied to production may increase energy production it may also discourage producers from testing innovative designs since, if the design does not perform as expected, no benefits will be realized. In addition, our analysis shows that the technologies that benefit most from a PTC are those with high capacity factors, i.e., base-load serving technologies such as geothermal. Peak and intermediate load technologies such as CAES, solar and wind are aided only by a very large PTC.

5. **Are there ways that utility ratepayers could more directly support research in new generating technologies? What would the federal role be through such mechanisms?**

The relationship between utilities and public utility commissions in early commercial applications of new generating and load management technologies is an important factor that will affect the deployment of these technologies in the 1990's. In particular, increased research, development, and demonstration activity will require utilities and utility commissions to agree on appropriate mechanisms for supporting such activities. Direct support alone from the rate base for research activities (such as the allowance for contributions to the Electric Power Research Institute) may be desirable and important, but they are not sufficient to assure extensive deployment of these technologies by the 1990's. Much larger commitments, however, that involve large capital investments such as major demonstration facilities may only be justified by a sharing of the risk between ratepayers, stockholders and, if other utilities would benefit substantially, taxpayers. One mechanism for supporting such projects is to finance a portion of a proposed project with an equity contribution from the utility and the rest through a "ratepayer loan" granted by the public utility commission. The public utility commission might argue that a candidate demonstration project is too risky for the ratepayer to be subsidizing it, particularly if other utilities could benefit substantially from the outcome if successful and are not contributing to the demonstration, i.e., sharing in the risk. In such cases, there could be a Federal role; for example, the ratepayer contribution to the demonstration could be underwritten by a Federal loan guaranty.

6. **If AFBC and IGCC technologies are well on their way to commercial deployment as a result of the current demonstration activity, what are reasonable candidates for the "Clean Coal Technology Reserve?"**

For the basic designs of the AFBC and IGCC, the current development and demonstration schedule appears adequate to allow these technologies to be ready by the 1990's. The transition from demonstration to early commercial units, however, will have to be accelerated if the technologies are to serve significant load in the 1990's. In this transition, variations in basic designs or more advanced designs to enhance performance characteristics may require additional research and development. Such variations including alternative gasification or liquifaction processes, alternative atmospheric fluid bed designs (circulating or bubbling beds) or fuel feed mechanisms (over or under bed feed systems), and pressurized fluid beds would be good candidates for the clean Coal Reserve. In addition, shorter term enhancements to conventional technologies such as coal cleaning, limestone injection, or coal-water fuel mixtures are all logical candidates for the clean coal reserve.

7. **Have your investigations led you to any ideas regarding the "non-utility" role in the commercial development of new technologies? If so, please describe.**

P. Blair 3/5/85 Testimony Questions

While traditionally conservative in adopting new technology, the electric utility industry has grown particularly cautious in the wake of its experience with nuclear power. Perhaps because of this caution and higher returns on investment, projects initiated by non-utility power producers under the Public Utility Regulatory Policies Act (PURPA) since 1978 have served as the principal test bed for first generation commercial applications of many new generating technologies. For example, wind turbine technology and small AFBC boilers in cogeneration applications are maturing largely through such projects. Non-utility power producers are likely to continue to be an important force in commercialization of new electric power technologies, although the magnitude of this contribution will depend on future tax treatment of such investments and trends in avoided costs.

8. To date, which class of investors has been the most important in developing the new technologies being examined by OTA: electric utilities or other sectors?

The technologies analyzed by OTA fall into two basic groups: (1) those envisioned primarily in electric utility applications, including the IGCC, large (> 100 MW) AFBC, large (> 100 MW) CAES, large (> 50 MW) geothermal plants, utility-owned fuel cell power plant (multi-megawatt), and solar thermal central receivers and (2) those characterized as suitable either for utility or non-utility applications, including fuel cells (< 1 MW), small AFBC (< 100 MW), small (< 100 MW) CAES, wind, small (< 50 MW) geothermal plants, batteries and other solar technologies such as photovoltaics and parabolic dish solar thermal units. For the most part, those in the first group are being developed in utility applications and those in the second group are being developed in non-utility applications, although some utilities in the southwest have been active in the development of photovoltaics and solar thermal technologies from the second group.

9. **Between the electric utilities and non-utility customers, are there any indications of which will be the most important investors in these new technologies over the next fifteen years?**

We expect the distinctions made between the two groups of technologies articulated in the response to the last question to hold well into the 1990's as long as PURPA excludes utility ownership in qualifying facilities, avoided costs remain sufficient to attract non-utility investments, and the renewable tax credits are not terminated abruptly. The utility involvement in development of these technologies could increase if, for example, public utility commissions provided incentives such as ratepayer loans for such projects or increased allowances in the rate base for research, development, and demonstration efforts.

10. **Does the available data allow you to adequately assess the present importance of the demand for these technologies in the non-utility sector.**

Only in the most general sense. The U.S. Department of Energy stopped collecting statistics on non-utility electric power production in 1981. Data reported for subsequent years in such publications as the Edison Electric Institute Statistical Yearbook are extrapolated from pre 1981 trends which we suspect are misleading. Even the Federal Energy Regulatory Commission's collection of data concerning applications qualifying facility status under PURPA has not yet been analyzed to determine how much of this capacity has actually been built. Until better data are gathered only the most general observations can be advanced regarding the relative role of non-utility power production in overall U.S. electricity generation.

11. **Do available statistics on future capacity expansion plans adequately incorporate the contributions of the non-utility sector to new generating capacity during the next fifteen years?**

No. The North American Electric Reliability Council's (NERC) data on future expansion plans are not consistent across regions with respect to inclusion or not of future non-utility generating capacity. This is attributed by NERC to differences in utility reporting practices.

12. **If non-utility generating capacity additions are not adequately reflected in current projections, how might statements regarding the need for additional utility-owned generating capacity change if the non-utilities were given full consideration?**

For some regions the non-utility contribution may be insignificant currently and for the foreseeable future but for other regions, particularly California and Texas, the contribution of cogeneration, small power production and industrial self-generation (not grid connected) is already fundamentally altering the capacity expansion plans of many utilities. For example, Houston Lighting and Power now plans for over 30 percent of is installed capacity to be in the form of industrial cogeneration by the turn of the century. The California Public Utilities Commission recently placed a moratorium on new PURPA qualifying facility applications because current applications alone may exceed generating capacity needs for many utilities.

P. Blair 3/5/85 Testimony Questions

13. Given the cogeneration potential of atmospheric fluidized bed boilers, would you agree that the short payback period for industrial customers generating their own power needs while selling surplus power or waste heat will make fluidized bed boilers a very popular choice among industrial customers in the future?

Yes. Perhaps foremost among new technologies considered by OTA that offer the potential of substantial deployment in the 1990's are small (below 100 MWe) AFBC plants in cogeneration applications. Over a dozen commercial cogeneration plants using AFBC have already been initiated by non-utilities. The prospects are good that additional orders--perhaps mostly from non-utilities--will be forthcoming and that large numbers of these AFBC units could be operating by the end of the century.

14. Recent cogeneration activity has prompted an interest in evaluating this technology in terms of economic efficiency. Given your review of new electric power technologies for the 1990's, would a measure such as lowest rate to ratepayer convey the full range of economic benefits to be derived from such a technology? What other measures of merit might be included to determine the value of this technology?

No. Clearly the direct and most immediate economic benefits of cogeneration applications of both conventional and new technologies stem from increased overall energy efficiency and hence lower costs to generate electricity. These lower costs can be passed along to the ratepayer in the form of lower electricity rates. In the long term, however, other benefits of increased penetration of cogeneration and small power production may benefit the ratepayer as well. Such benefits which may be more difficult to quantify include: increased reliability due to a larger number of smaller generating units which in turn reduces the necessary generating reserve margin; improved quality of service if generators are located closer to load centers; lower asset concentration and reduced investment risk for utilities and hence improved security ratings and a lower cost of debt; increased technology and fuel diversity; reduced transmission requirements; and improved area control. These other benefits could result in an overall reduction in the cost of service and, hence, lead to reduced rates.

The controversy over the economic benefits of cogeneration, particularly with respect to most current natural-gas fired activity, results from disagreements over the allocation of near-term benefits. The current system of allocating these benefits came about as a result of PURPA which, for the most part, in an effort to stimulate cogeneration and small power production, accrues most of the near-term benefits to these producers, at the expense of the ratepayer. This is accomplished by awarding full-avoided cost to small power producers for the electricity that they generate. That is, under the current system, ratepayers are giving up the near-term benefits of cogeneration and small power production in the hopes that there will be significant long-term benefits. If avoided costs are high then the near-term benefits may be more than sufficient to attractive investment in PURPA qualifying facilities. Such as situation suggests that the near-term benefits could be shared with the ratepayer without destroying the incentives for non-utility investors to develop cogeneration facilities..

P. Blair 3/5/85 Testimony Questions

We have not examined other measures of merit that captures the overall economic benefits of cogeneration. Any individual measure of merit may be misleading anyway since the value of the long-term benefits are likely to vary considerably by utility. For example, if a utility's generating capacity is dominated by several very large coal or nuclear units then the benefits of reducing the reserve margin with a larger number of small generating units including cogeneration will occur only with a very large complement of such units. This is because the reserve margin in this case is dictated by the necessity to cover planned and forced outages of the large units rather than a percentage of total installed capacity.

15. **The technical potential for cogeneration has been estimated by OTA to reach over 200,000 MW in the U.S. by the year 2000. Yet actual implementation will be considerably less, given the broad range of economic and institutional considerations. Please describe significant barriers with respect to obtaining access to transmission services that currently hinder commitment to the development of cogeneration and small power production.**

In some areas of the country, most notably California, obtaining access to transmission has surfaced as an important impediment to further interconnection of qualifying facilities (QF's) under PURPA. Part of the controversy centers around who will bear the cost of necessary upgrading or expansion of transmission capacity to accommodate new QF's. Utilities argue that such costs should be borne entirely by the QF. QF's argue that if utilities integrated future non-utility power production more completely in their resource plans, reconfiguring of existing transmission capacity as well as planning for new capacity would result in lower costs overall as well as an allocation of costs between utilities and QF's. While the problem has really only surfaced to date in California and has been put off temporarily by a moratorium on all interconnections under PURPA in that state, as the opportunities for cogeneration and small power production increase the issue will be come more critical.

Access to transmission services may also include the provision for wheeling cogenerated power to distant utilities (which may have higher avoided cost rates) or, in some instances, directly to end-users. Some states mandate utilities to accommodate such wheeling in their implementation of PURPA but many do not. Utility concerns about impact on system operation and performance and the costs of new transmission to accommodate wheeling (or to use utility capacity that cannot use existing transmission capacity because it would be already committed to facilitating wheeling) are usually cited in their reluctance to accommodate wheeling. In the case of wheeling to non-utility customers, utilities charge that permitting such activities amounts to "cream skimming" of their best customers.

PUBLIC SERVICE COMMISSION
STATE OF NEVADA

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May 24, 1985

The Honorable Don Fuqua, Chairman
Committee on Science and Technology
Suite 2321 Rayburn House Office Building
Washington, DC 20515

Dear Congressman Fuqua:

Thank you for the opportunity to expand upon my testimony before the Subcommittee on Energy Development and Applications on March 5, 1985. Attached are my responses to the additional questions of Members of the Subcommittee that you sent me on May 13.

If you have any further questions, I would be most happy to answer them.

Yours very truly,

Stephen Wiel
COMMISSIONER

SW:ch
Enclosures

Responses to Hearing Questions - March 5, 1985
Subcommittee on Energy Development and Applications

Commissioner Stephen Wiel

Q. Would you please provide the Subcommittee with some additional background information on the "least-cost" concept that you described in your testimony?

A. The phrase "least-cost" was coined by Dr. Roger Sant, former energy official under Presidents Nixon and Ford, who developed this concept while director of the Carnegie-Mellon Energy Productivity Center. The least-cost approach, also referred to as a cost-minimizing strategy, takes a broader perspective than traditional energy supply forecasts and analyses by including efficiency measures and technologies as an additional, reliable "energy supply" option. As Sant et al. noted in their 1979 report, Least Cost Energy Strategy: Minimizing Consumer Cost Through Competition, Americans would have bought about 28 percent less oil, 34 percent less coal and 43 percent less electricity and would have spent 17 percent less money in 1978 than they actually received, if, for the decade before 1978, they had simply bought at each opportunity the cheapest means of providing their energy services.

Dr. Sant et al. have updated and refined this approach in their 1984 publication, Creating Abundance: The Least Cost Energy Strategy (McGraw-Hill). An essential component of the least-cost energy strategy involves looking at cost-effective ways of supplying or avoiding energy at the scale and the quality appropriate to the task at hand, so as to provide that energy service at least cost to the consumer. This engineering/economic discipline has given rise to "energy service" enterprises that market energy-saving and electricity-saving techniques.

"In some respects," notes Sant, "the concept of energy service businesses is similar to the emergence of the concept in the health field of health maintenance organizations (HMOs)." Sant observes that as the cost of doctors, sophisticated equipment, and hospitals increased, one way to reduce the cost of health care was to spend money on preventative health services in order to avoid more expensive correctional treatment later. Another was to increase the efficiency of funds spend on health care by avoiding using a highly trained, experienced doctor to perform duties that someone less expensive could accomplish or by not leaving a person in a hospital room longer than necessary. The conventional approach primarily has patients purchase doctor services and hospital services only after illnesses have arisen. Under the HMO alternative, individuals contract with HMOs for continuing health services. The HMO approach takes advantage of long range planning. " Thus, through preventive care and the efficient use of doctors, paraprofessionals, hospitals, and equipment," Sant says, "an HMO might reduce the cost of health care to the consumer while increasing its profits at the same time."

The scope of opportunities represented by very cheap efficiency measures was brought to the attention of Congress by the 1980 least-cost energy report prepared for the House Energy, Conservation and Power Subcommittee by the Solar Energy Research Institute entitled, A New Prosperity: Building a Sustainable Energy. Based on available 1980 cost-effective efficiency measures and technologies, the report found that a market-oriented opportunity existed for supporting vigorous national economic growth while displacing 15 million barrels of oil equivalent per day. The net energy savings to consumers, communities and companies by the turn of the century could equal several trillion dollars. Since then, two global least-cost studies have been performed -- one by the West German government (Least Cost Energy: Solving the Carbon-dioxide Problem) and the other by the World Resources Institute (Low Energy Global Future) -- showing similarly robust savings.

As far back as 1975, the state of California initiated a modified least-cost energy development policy with the passage of the Warren-Alquist Act, resulting in multi-billion savings for California consumers to date. A regional least-cost electrical approach was mandated for Idaho, Oregon, Montana and Washington in 1980 with the passage of the Northwest Electric Power Planning and Conservation Act. Many energy experts argue that the passage of Public Law 95-92, the Department of Energy Organization Act, mandate federal efforts to transition the United States from dependency upon high-cost/high-risk energy supplies to reliance upon low-cost/low-risk ones; goals which have yet to be implemented or even rigorously addressed.

Several years ago the American Public Power Association, representing 2000 publicly-owned and operated utilities, officially adopted least-cost energy planning policies. This is described in detail in their 1984 volume, The Next Ten Years: A Strategic Guide for Public Power, which makes a convincing case that utilities need to recognize that they can profitably shift their role from strictly being a supplier of resources to also being a purveyor of energy services. As then-chairman of the Tennessee Valley Authority (TVA), S. David Freeman, described it, TVA is "building" thousand megawatt plants in the attics of its customers by insulating these attics - because it is the cheapest energy supply.

The least-cost concept is a constantly evolving one as scientific and technological breakthroughs continue to flood the marketplace with commercially competitive energy service products. I have attached Amory Lovins, keynote speech at N.A.R.U.C.'s last annual convention, which provides another brief, albeit fascinating, look at this evolving market.

Q. What states are currently engaged in "least-cost" planning procedures?

A. There are at least ten states that prominently feature full or partial least-cost planning procedures and policies. As I noted above, since 1975 California has promoted such an approach, and since 1980 and the four Northwest states have been doing so. Two years ago my own state of Nevada enacted what we think is the most comprehensive least-cost approach; it is a resource assessment model that integrates supply measures and conservation measures on an equal footing. I have attached a paper that was given at the 1984 American Council for an Energy Efficient Economy (ACEEE) Summer Study on Energy Efficiency in Buildings that describes our process in more detail. The paper also compares Nevada's least-cost approach with those found in the states mentioned above, as well as Florida, New York, Ohio and Wisconsin.

N.A.R.U.C.'s Committee on Energy Conservation is currently conducting a survey of least-cost planning activities in all the states. Initial responses are showing that many additional states are currently introducing least-cost planning procedures.

Q. How many state utility regulatory commissioners have expressed support for the least-cost planning approach? How many commissions have expressed an interest in this initiative?

A. There was unanimity in passing N.A.R.U.C.'s least-cost resolutions at its annual convention. Representatives were in attendance from all 50 states as well as 12 territories and Canadian Provinces.

My answer to the previous question lists ten states with some form of least-cost planning. My own conversations with commissioners from these states indicate that these programs enjoy continuing support and that there is a keen interest in expanding and refining them. In addition, the Commissions from Colorado, New Jersey and Virginia have each made written requests of the Nevada Commission to supply information to support the development of similar programs in their own states. Furthermore, my personal experience when talking with other commissioners and commission staff members is that as soon as I say I am from Nevada there is immediate enthusiasm and extensive inquiry about our integrated resource assessment process. I have spoken to commissioners from at leat thirty states who have expressed a general interest and support for least-cost planning. The level of interest ranges from active efforts to institute a similar program to a more casual wait-and-see attitude. The goal of N.A.R.U.C.'s proposal here is to convert commissions from the later category to the former and to help all of them with their implementation of least-cost energy programs.

Q. What is the unique nature of N.A.R.U.C. that qualifies it to help state utility commissions implement least-cost planning procedures?

A. Supplying least-cost energy to the public requires appropriate investments by utility companies. Utility companies are significantly influenced by their regulatory commissions. N.A.R.U.C. is the association of those commissions.

For 96 years, N.A.R.U.C. has been dedicated to assisting its state membership in staying abreast of technical, financial, regulatory, policy and institutional changes that would otherwise be simply impossible for any one state to do. State commissioners place great trust in N.A.R.U.C. in performing essential roles such as information exchange and updates, distributing key materials, holding special seminars, and providing other unique tasks.

The unique relationship between N.A.R.U.C. and its state members can also provide especially valuable feedback to federal officials at DOE and other agencies. The information gathered through exchanges between and among state utility commissioners and their respective utilities offers an opportunity for DOE to assess its own programs and budget priorities and to progress towards achieving the goals of Public Law 95-91.

While commissioners in general have expressed support for N.A.R.U.C's least-cost resolutions, most have not had the opportunity to explore this in depth within their own state. They continue to look to N.A.R.U.C. for guidance.

Q. Why aren't utilities already making these least-cost investment decisions?

A. First, there is a long utility tradition and experience directed towards constructing large power plants because of historical economies of scale. As I described in my testimony this has been changing since the late 1960's. Most utility managers, however, continue to look to this historical model for continued investment practices.

Second, efficiency measures and technologies for saving energy and electricity are still relatively new and unfamiliar to utility managers. Half the available electricity-saving efficiency measures only entered the commercial market within the past several years.

Third, utility executives have as their primary charters to provide sufficient electricity for anyone that wants it, so there is a tendency to overinvest in the most familiar technologies - large powerplants. Utility commissioners, on the other hand, have historically tried to balance this by restricting investments that cause unreasonably excessive reserves of electricity capacity. An obvious problem here is demand uncertainty; what is going to be the actual growth rate of demand? Utilities are suddenly finding that the long lead-time of capital intensive powerplants can leave them financially strapped if demand suddenly evaporates and the plant is no longer useful.

For example, efficiency experts have identified over 200 large powerplants' worth of electricity savings by the full use of efficient light bulbs, refrigerators and other appliances and motors at "delivered" costs of several cents per kilowatt-hour. The key question that looms on every utilities' and PUC's planning horizon is: what saturation level of these efficiency measures do you project? Insufficient planning could lead to excessive overconstruction, rate shock, or even utility insolvency. As several utilities have shown in adopting least-cost programs and planning policies, utilities are in a unique position of reducing both the uncertainty of future demand and the cost of hedging against the remaining uncertainty by looking at ways they can capture the growing least-cost market opportunities.

Fourth, most utility executives respond to how they expect their commissioners to treat their actions, and they never can know for sure how their commission will respond to their doing something new. Traditional ratebase treatment is not obviously favorable to least-cost investments such as efficiency measures that save kilowatt-hours rather than generating them, even though these saving kWh may be an order of magnitude less costly than traditional powerplant investments. There is a strong tendency for utility executives to avoid these uncertainties.

California and Nevada, as pointed to in the attached ACEEE paper, have demonstrated that you can change the regulatory climate and foster an environment that induces utilities to entertain a wider range of investments than traditionally considered. These changes can reduce both the level of uncertainty and the cost of hedging against the remaining uncertainty. Unfortunately, the widespread lack of good information and analytical planning tools in many states has kept them from moving in this preferable direction.

Q. Please describe in detail the analytic planning tools you mention in your testimony that would be developed with federal resources.

A. N.A.R.U.C. would use the funds to jointly carry out the following research to fulfill our analytical needs and provide technology transfer. Lawrence Berkeley Laboratory's Energy Efficient Building Program would conduct the first three tasks and would assist N.A.R.U.C. with tasks 4 and 5.

1. The development of a Technology-Cost-Curve database that consists of an inventory of commercially available efficiency measures, methods, and technologies capable of cheaply and reliably supplying or avoiding energy and power, primarily in the residential and commercial sectors. The database would include foreign technologies as well, providing a "forecast" of competition likely to enter the domestic market from abroad. Graphically illustrated summaries of the technology cost curves would preliminarily indicate how much energy/power supply each efficiency measure could provide at what "delivered" price to a given utility company. The detailed data would be available to each utility for use in developing company specific least-cost resource plans.

2. The development of a Stocks-and-Flows database comprised of an inventory of end-use, energy-consuming and electricity-consuming devices found in utility service districts. The database would also include the amounts of energy consumed and the frequency and duration of use (in order to look at ways of saving peak loads as well as base loads). The database would include both existing and new stocks. The data base would consist of roughly a dozen utility service districts, providing generic information upon which other utility service districts can build and design specific efficiency programs.

3. The development of a Monitoring, Analysis and Quality Control database, to verify the reliability of efficiency measures. The database would enable confirmation of what elements of the efficiency measures are actually performing as planned and why other elements are not.

4. The development of a Policies and Information database that would provide an exchange between state commissions on orders, regulations, rate treatment, case histories of efficiency programs, utility experiments, related laws and innovative incentives and rebate programs.

5. Preparation and dissemination of a Methodology Handbook for performing integrated demand side-supply side analysis of least-cost electricity and gas; distribution of materials produced from the established databases; preparation and dissemination of a program development handbook for commissions; and holding of seminars for commissioners, staff members and utilities on the use of the above materials.

Q. What resources would be necessary to implement the least-cost planning initiative you have discussed in your testimony?

A. Considerable resources for carrying out these tasks is already being undertaken by individual state commissions. The specific funds requested by N.A.R.U.C. to be included in the Fiscal Year 1986 DOE budget to supplement these efforts amounts to $4 million. The requested sum would be jointly utilized by N.A.R.U.C. and Lawrence Berkeley Laboratory's Energy Efficient Buildings Group to develop and implement the databases for use by state utility commissions and the utilities within their jurisdictions.

Q. Is the Department of Energy currently funding R&D related to the least-cost planning initiative?

A. I cannot knowledgeably comment upon the entire DOE budget. I do know that DOE does not presently provide any funding to N.A.R.U.C. related to the least-cost planning initiative, technology transfer, or analytical research described in our request for funds to work with state utility commissions.

Q. Why is it necessary to provide federal funding for the least-cost planning initiative? Can't state utility regulatory commissions set guidance to utilities on conducting these least-cost planning analyses?

A. The major impediment to state utility regulatory commissions setting guidelines and providing guidance to utilities for developing least-cost planning analyses is understaffing and underfunding. Furthermore, it is a vast waste of time, professional talent, and limited budget monies for each state to reinvent the wheel on least-cost planning components. Much of this information is regional and national in scope. It lends itself much more easily and cheaply to being assembled and distributed by a national organization such as N.A.R.U.C., which already interfaces with states and regions. Indeed, achieving the high quality of analytical planning tools and information database of the magnitude that we think is desirable is simply beyond the financial and staff capacity for any one state to handle.

Finally, it would clearly seem in line with both the letter and spirit of Public Law 95-91, the Department of Energy Organization Act, that N.A.R.U.C. could be of inestimable value in fulfilling the law's mandate to help in the transition of the United States from dependency upon high-cost/high-risk energy supplies to reliance upon low-cost/low-risk energy services. This was the express intent of N.A.R.U.C.'s support in unanimously passing the least-cost energy resolutions at its recent annual convention.

The Federal funds requested are not in lieu of state utility commission and government funding but would be an adjunct to ongoing efforts. The federal support N.A.R.U.C. is requesting is but a small part of person-years and institutional support already in place in every state across the nation.

Q. Please provide copies of the N.A.R.U.C. conservation resolutions and a copy of Mr. Amory Lovins' keynote speech to N.A.R.U.C., for inclusion in the record.

A. Copies are enclosed.

NARUC Convention Resolution No. 5

Resolution Supporting the Adoption of National Energy Goals

WHEREAS, There are national imperatives which require renewed vigor in the development and implementation of national energy policy; and

WHEREAS, The Nation continues to be dependent upon petroleum and other non-renewable resources as energy sources; and

WHEREAS, Existing national and international energy policies and conditions do not preclude the recurrence of serious problems arising from this dependence; and

WHEREAS, The increase in energy prices has a major adverse impact on the Nation's citizens and its economy; and

WHEREAS, Conventional sources of energy are subject to constraints involving supply, transportation, cost, environmental, health and safety considerations; and

WHEREAS, The Nation must devise strategies by which to address these problems including, but not limited to strategies to assure adequate, efficient, reliable energy supply and to avoid unnecessary and wasteful consumption; and

WHEREAS, Cost effective energy conservation measures can address such issues appropriately; now, therefore, be it

RESOLVED, That the National Association of Regulatory Utility Commissioners, assembled in its Ninety-sixth Annual Convention in Los Angeles, California, adopts the following goals and urges the government of the United States to find it in the interest of the nation to:

I. Assure adequate and reliable energy supply by using resources in the most efficient manner, by replacing energy resources vulnerable to interruption due to circumstance beyond the nation's control with those less vulnerable, and by encouraging the development and utilization of renewable resources;

II. Define conservation in terms of both avoidance of unnecessary and wasteful consumption and in terms of economic efficiency;

III. Promote conservation by encouraging consultative participation of states, local governments, consumers, energy companies, and the public at large in developing, implementing and updating plans and programs related to energy resource conservation and development;

IV. Improve utility conservation programs by raising consumer awareness to the benefits of conservation, by increasing consumer participation and by requiring utilities to develop programs to achieve implementation of audit recommendations;

V. Encourage development of least cost system plans for major gas and electric utilities in order to meet energy needs over the coming decades, which plans shall include the following: (1) conservation, (2) renewable resources, (3) use of waste heat or high fuel conversion efficiency and (4) all other resources;

VI. Concentrate additional federal efforts on strengthening the Department of Energy's ability to gather data, provide coordination and provide assistance to states and the public; on establishing national appliance efficiency standards; on requiring increased thermal efficiency in buildings; and on establishing energy efficiency in transportation; and

VII. Provide for the essential energy needs of the disadvantaged by providing utility incentives for the development of conservation and audit services, by providing increased permanent weatherization services for low income households, and by eliminating financial barriers to conservation improvements for the needy through loan or grant programs.

Sponsored by the Ad Hoc Committee on Energy Conservation

NARUC
Convention Resolution No. 6
Adoption of State Energy Goals

WHEREAS, There are national energy imperatives which are appropriately addressed at the State level; and

WHEREAS, State energy policies should be approached with renewed vigor in their development and implementation; and

WHEREAS, The Nation continues to be dependent upon petroleum and other non-renewable resources as energy sources; and

WHEREAS, Existing state, national and international energy policies and conditions do not preclude the recurrence of serious problems arising from this dependence; and

WHEREAS, The increase in energy prices has a major adverse impact on the nation's citizens and its economy; and

WHEREAS, Conventional sources of energy are subject to constraints involving supply, transportation, cost, environmental, health and safety considerations; and

WHEREAS, The Nation must identify state imperatives by which to address these problems including, but not limited to strategies to assure adequate, efficient, reliable energy supply and to avoid unnecessary and wasteful consumption; and

WHEREAS, Cost effective energy conservation measures can address such issues appropriately; now, therefore, be it

RESOLVED, That the National Association of Regulatory Utility Commissioners, assembled in its Ninety-sixth Annual Convention in Los Angeles, California, adopts the following goals and urges the states to:

I. Require development of least cost system plans for major gas and electric utilities for meeting energy needs over the coming decades, which plans shall include the following: (1) conservation, (2) renweable resources, (3) use of waste heat or high fuel conversion efficiency and (4) all other resources;

II. Assure increased cooperation and coordination among regions and states by maintaining and broadening the information base on energy use and related subjects, by encouraging energy planning, and by exploring ways to increase the use of power pooling and energy exchange;

III. Continue and develop additional incentives to encourage renewable resource used by adopting ratemaking treatments for conservation programs consistent with the existing treatment of conventional fuel procurement and power supply arrangements;

IV. Adopt legislation providing state regulatory commissions with the authority to compel participation in cost effective conservation programs by all utility companies;

V. Provide additional assistance for disadvantaged energy customers by developing means to improve low income and elderly participation levels in utility conservation programs, by providing additional outreach, training and referral services by developing programs to achieve implementation of audit recommendations; and

VI. Require increased thermal efficiency in buildings and new appliances.

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NARUC Convention Resolution No. 7

Resolution Supporting Adoption by State and Federal Regulatory Commissions of a Policy Mandating Electric and Gas Utilities to Develop and Submit for Approval Least-Cost Resource Plans

WHEREAS, It is imperative that the Nation exert more control over its energy future and acknowledge its inherent uncertainities; and

WHEREAS, It is necessary that demand and supply planning be fully integrated to ensure that resources are used prudently and that our energy needs are met at the least possible cost; and

WHEREAS, Energy conserved is a resource and should be subjected to the same need and cost-effectiveness standards as other resources; and

WHEREAS, Conservation can reduce growth in energy demand and thus reduce the need for the construction of new electric facilities; and

WHEREAS, Conservation should be viewed by utilities as an alternative to new supply options; and

WHEREAS, Implementation of this policy will provide the ability to select resources based on the most important factors: need, cost reliability and environmental considerations; now, therefore, be it

RESOLVED, By the National Association of Regulatory Utility Commissioners, assembed in its Ninety-sixth Annual Convention in Los Angeles, California, that State and Federal regulatory commissions should adopt a policy which bases the determination of need for new facilities on the development of a least cost supply plan which evaluates and incorporates all cost effective conservation, load management and alternate energy sources in the least cost supply plan; and be it further

RESOLVED, That least cost resource plans should include consideration of the following: (1) conservation; (2) renewable resources; (3) generating resources using waste heat or generating resources of high fuel conservation efficiency; and (4) all other resources.

Sponsored by the Ad Hoc Committee on Energy Conservation

SAVING GIGABUCKS WITH NEGAWATTS

Address to Panel "Energy Conservation: A Cornerstone of National Independence"
96th Annual Convention, National Association of Regulatory Utility Commissioners
Los Angeles, 26 November 1984
by

Amory B. Lovins, Director of Research
Rocky Mountain Institute

ABSTRACT

New technologies for using electricity more productively--most of them new on the market in 1984--can provide twice the savings, at a third the real cost, that was possible five years ago. Specifically, full use of the best electricity-saving measures now available at under 2¢/kW-h (1984 $) could ultimately quadruple the efficiency of using electricity in the United States. That potential can be reliably achieved over approximately the life of a power station.

This implies that 80-90% of the electricity now sold is uncompetitive with efficiency improvements now on the market; that probably every thermal power plant in the country is economically obsolete, eventually requiring the writeoff of $100-200 net billion worth of plants; and that rate hikes may reduce utilities' long-run revenues by pricing their product even further out of the market.

Nor is this potential purely theoretical. Since 1979, the U.S. has gotten more than a hundred times as much new energy from savings as from all net expansions of energy supply; more new supply from renewables than from nonrenewables; and more new generating capacity ordered from small hydro plants and windpower than from coal or nuclear plants or both, not counting cancellations. Even wood now delivers twice as much energy as nuclear power. For fundamental reasons, the age of the big power plant is over. To survive, utilities must seek to reduce their risks to an affordable level, buying only options which are small, fast, and cheap--above all, options which use electricity more efficiently.

We are now in a age of costly electricity and cheap efficiency. Smart utilities will therefore sell less electricity and more efficiency. They will market "negawatts" (saved electricity) and use new ways to finance their customers' savings. The same efficiency gains which, if not properly managed, could quietly take away most of the existing market for electricity also offer alert utilities an unprecedented opportunity to control risk, improve cashflow, secure market share, and save operating costs--becoming once more a declining-cost industry.

The savings practically achievable from this competitive approach are so large that, for example, investors in abandoned plants could be made whole (even with a return) while lowering the rates--a "no-losers" approach to abandonments. Acid rain, too, could be abated by electricity-saving devices at a negative net cost. Nationally, the cumulative net savings from a least-cost energy strategy, just by the year 2000, would more than suffice to pay off the entire National Debt.

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SAVING GIGABUCKS WITH NEGAWATTS

Remarks Presented (in Abridged Form) to the Panel
"Energy Conservation: A Cornerstone of National Independence"
at the
96th Annual Convention, National Association of Regulatory Utility Commissioners
Los Angeles, 26 November 1984

by

Amory B. Lovins*, Director of Research
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An economic and institutional revolution is sweeping electric utilities. Behind it is a quieter technological revolution: an astonishingly powerful, diverse, and rapidly emerging array of devices to wring more work from a kilowatt-hour. I appreciate this opportunity to outline for you the dimensions of these changes; how they are transforming utilities' strategic-planning imperatives; and how they can make your regulatory task more productive, consensual, and pleasant.

This talk will by necessity be general and omit many details (treated in recent publications) which can be amplified in discussion. But it will explain the consequences which flow from one premise: that people want, seek, and will eventually find the amount, type, and source of energy that will deliver each desired energy service (such as comfort, light, shaftpower, and electrolysis) in the cheapest possible way consistent with reliability and convenience. Such a neoclassical competitive marketplace for energy services, in which electricity will be bought only where it is the best buy—the option with lowest private internal cost—is of course a theoretical construct. The actual market is a highly imperfect fuel bazaar, satisfying no condition of the ideal free market. Yet, as I shall show, it is beginning to behave remarkably like a free market, profoundly altering the prospects for electrical demand. Let me start with the bottom line:

- Full use of the best electricity-saving measures now on the market could quadruple the efficiency of using electricity in the United States—using measures whose average cost is less than about 2¢ (1984 $) per kW-h saved.
- Since such savings cost less than just operating existing fossil-fueled or nuclear plants, such plants—even if just completed—cost less to write off (and displace with efficiency) than to run.
- Of all power now generated, at least 80% at today's average price, and nearer 90% at marginal price—that is, the output of every thermal plant in the country—can't compete with efficiency improvements now newly on the market.
- As that "overhang" of efficiency is purchased over the next few decades, making the plants' uncompetitiveness manifest, some $100-200 billion worth of unamortized thermal power stations may have to be written off.

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†Rocky Mountain Institute is a nonprofit educational and research foundation whose dozen staff explore the connections between energy, water, agriculture, security, and economic development. The Institute's Energy Program steers both utilities and their customers towards better buys. To this end, RMI provides the consulting services of a consortium of leading utility-reform analysts to electric utilities and their regulators, financiers, customers, and suppliers.

- By grossly underestimating the power of "technical fixes" to use electricity more productively, a $0.3-trillion industry is continuing to liquidate itself to build hundreds of plants it can't afford, won't need, and won't be able to pay for--playing You Bet Your Company that its customers will take half a century to discover better buys*.
- Future demand--that is, how long it will *actually* take the customers to discover least-cost options--is not a fate to be prophesied by examining the entrails of forecasters; it depends on customers' access to information, capital, and freedom of choice. It is a variable to be influenced according to policy goals. Utility experience now shows that implementation of efficiency is or can be made faster and more reliable than building plants.

The savings available today are twice as big, and cost only a third as much, as those identified five years ago†. Most of today's very best electricity-saving technologies were not available even a year ago. What are some of them?

- A Norelco SL-18 light bulb uses 18 watts of electricity, but produces the same amount of light as a 75-watt incandescent bulb and lasts over 13 times as long. It also gives light of better quality: special fluorescent phosphors give nearly perfect color rendition, and a high-frequency solid-state ballast eliminates flicker and hum. If you screw one of these quadrupled-efficiency lightbulbs into a socket, replacing 75 watts with 18, you are effectively installing on the grid a 57-watt power plant, dispatching 57 "negawatts," or unused watts, back to the utility to sell to somebody else. The SL-18 repays its high retail cost ($21 each in lots of six) 2-3 times over by saving $40 worth of electricity at 7¢/kW-h, plus a dozen replacement bulbs (about $10 worth), plus the labor cost of installing them. When universally used (which should take 10-15 years), SL bulbs and their cousins will displace some 30 GWe of installed U.S. capacity at about 1-2¢/kW-h. The gross value of the electricity saved will exceed $8 billion per year.
- High-frequency electronic ballasts improve the quality of fluorescent light and can save about 40% of their electricity, paying back in about a year. Automatic dimming by a daylight-sensing photocell can increase the direct saving to 70-90%. Such ballasts, costing about 0.5¢/kW-h, can displace 25+ GWe directly, plus 15+ GWe more by reducing air-conditioning loads.
- Daylighting retrofits, better lights, and improved mechanical systems can shift the balance point of typical deep-plan office buildings by at least 40°F with a payback time of a year or two. (Thus a building which currently needs air conditioning at outside temperatures above, say, 50° could now do without it up to 90°.) Recirculation of ventilation air through floor-slab channels can also shift any residual air conditioning to the middle of the night. Even rudimentary retrofits of U.S. commercial buildings have cut electric demand by an average of 29% with a payback of about eight months. In the best new office buildings from Reno to Stockholm, *no* space conditioning is needed, yet capital cost is *reduced* by savings on mechanical systems. Similarly, a new office building in Jamaica's tropical climate cut electric use by about 90% at no extra capital cost. New retrofit techniques can cut

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*In effect, most utilities today are repeating the errors of the 1960s, when many underestimated demand and were caught short. They erred then in three ways: they paid little attention to end-use markets; they underestimated price elasticity in a period of falling real price; and in particular they underestimated the efficacy of entrepreneurs who were out in the marketplace selling comfort and convenience--which in those days meant air conditioners. Suppose that a utility makes the same mistakes today: not doing detailed end-use analyses, underestimating price elasticity in a period of *rising* real price, and underestimating demand for comfort and convenience--which nowadays means greenhouses and weatherstripping. By making exactly the same mistakes as two decades ago, a utility today could *overestimate* demand and *overbuild*. Many are doing so.

†E.g., Roger Sant's pioneering 1979 least-cost analysis showed that with 1978 technologies and prices, about 43% of the power sold cost more than efficiency.

most houses' space-conditioning loads by 90-100% with paybacks generally around 5-10 years at present oil prices—less with all-electric homes.

- Straightforward design improvements can more than quadruple the efficiency of household appliances. For example, among the biggest users (refrigerators), the best mass-produced model, by Toshiba, uses a third as much electricity as an average U.S. model the same size: Toshiba has made its refrigerators 5.5x more efficient in ten years and is still improving them at the same rate. The best refrigerator in pilot production is about eight times as efficient as the U.S. average. The best prototype (which I'm installing this month) is 100 times as efficient—a 99% saving. Its payback is about 5-6 years at handmade prices, and should be about zero when it's eventually mass-produced. Such refrigerators can ultimately displace 25 GWe of installed U.S. capacity; other efficient appliances can save about 33 GWe.
- The photocopier in our office uses about a tenth the usual amount of electricity, because it sets the toner with a cold compression roller instead of a heated drum. New computers use 80-90% less power than mid-'70s models.
- New methods of properly sizing, coupling, and controlling electric motors typically double the practical drive efficiency at under 1¢/kW-h. This one saving would displace over 70 GWe, or every nuclear plant in the country.
- A $15,000 microcomputer control for a giant compressor can save $500,000 on its annual energy bill while greatly reducing its downtime.
- The best aluminum smelters save about 40%, and if Mitsui's experimental coal-fired aluminum-smelting blast furnace works commercially, it'll smelt aluminum using no electricity. Furthermore, many structural uses of aluminum and steel will probably be displaced by composites within this decade.
- Advanced Swedish pulp- and papermaking processes could save about 67% of the fuel and 42% of the electricity used by Swedish plants in 1975 (which were more efficient than most U.S. plants are today), cost-effectively at under 2.3¢/kW-h. Many chemical processes show even larger savings.
- At the same price, all of Swedish industry—the world's most energy-efficient, and more biased than U.S. industry towards energy-intensive products—can double its electrical efficiency, using advanced technologies which are now starting to enter the market.
- Technological progress is rapid even in the most mundane areas. The best commercially available windows (R-5.4 argon-filled Heat Mirror™) insulate twice as well as triple glazing, cost less, and typically gain more winter heat than they lose, even facing due north. R-11 to R-19 windows and half-inch-thick R-30 insulation using evacuated glass beads are now experimental.

The effectiveness of many of these newly available electricity-saving measures is illustrated by a 4000-square-foot house/indoor farm/research center which my wife and colleague Hunter and I recently built at 7100' in the Rockies—an 8700-degree-day climate with temperatures down to -40°. The building needs no heat: it passively captures a third more than it needs, and we vent the excess. It provides uniform comfort year-round with zero backup. It also uses only about 0.12 W/sq ft of electricity--less than a tenth the usual amount—and a third the normal amount of water. Our total energy bill for all purposes (two-thirds of it for office equipment) is under $320/year, or 8¢ per square foot-year--about 5% that of a normal office building. The net marginal cost of our energy-saving measures, 1% of construction cost, pays back in one year. The building produces more than $19 per day worth of saved energy—economically equivalent to a 0.7-barrel-per-day stripper well. That saving should pay off the entire building in about 40 years. Our 2,500 visitors have also remarked on how the building combines efficiency with beauty and a very high quality of life.

Even if technological development were instantly arrested at its present stage—rather than continuing to evolve so quickly that it takes a looseleaf mind to keep up with it—the technical and economic potential for saving electricity is already immense. It will greatly widen the 2:1 margin by which present U.S. generating capacity saturates the premium (non-thermal) markets—the uses which can give us our money's worth from a form of energy as costly as electricity.

The new electricity-saving technologies of which I have given a few examples are relatively so cheap, and collectively so large, that:

- the long-run supply curve for electricity is so flat and slopes so gently that the market-clearing price will never be high enough to justify building more central thermal power stations. The era of big plants is over.
- the long-run own-price elasticity of demand for electricity is extremely large: so large that higher prices will probably *reduce* utility revenues. A utility which raises its rates will probably lose more on the number of kW-h it sells than it makes up by charging more per kW-h. If so, new construction will require more revenue but yield less—a recipe for bankruptcy. Long-run revenue can be increased only by lower price, not by higher price.
- higher prices (in other words) will make electricity even more uncompetitive with efficiency by pricing it further out of the market: rate hikes make electricity even less able to compete with weatherstripping. Electricity is already priced, in general, above a monopolist's profit-maximizing level, and must be sold at lower prices if it is to recapture market share. (Higher subsidies don't help either: they just encourage and enable utilities to build more plants than can be amortized from their revenues.)
- there will be fierce competition for shares of a shrinking fuels-and-power market—yet whether the real price of electricity is more stable than that of fuels is irrelevant because *neither* can compete with efficiency.
- a rising electric *share* of end-use energy does not mean rising electrical *demand*: many international analyses* foresee a rising electric share of a *dwindling* end-use market (just what has happened in the U.S. lately).

These long-run conclusions are not just theoretical; they are what the market is doing. Since 1979 the United States has gotten *more than a hundred times* as much new energy from savings as from all net expansions of energy supply combined. The energy content of a dollar of GNP has fallen by a fourth in the past decade—not through the sophisticated means I described, but mostly through such simple measures as caulk guns and duct tape. Even though the energy/GNP ratio continues in free fall by several percent per year, we have barely scratched the surface of how much efficiency is available and worth buying.

Of course, the *electricity*/GNP ratio has so far been more durable than the primary *energy*/GNP ratio—though that durability is often exaggerated: for example,

- electric demand grew slower or fell faster than GNP in six of the past ten and in five of the past seven annual intervals;
- electric demand has lately risen only about 80-90% as fast as GNP, and this elasticity is trending downwards;
- the electricity/GNP ratio has fallen since 1977—steadily since 1979;
- at least 15% of U.S. economic activity, and the fastest-growing part, is in the "gray economy" not reflected in the electricity/GNP ratio;
- in any event, correlation is no evidence of causality†—as we discovered in the past decade, when the supposedly sacred and immutable causality inferred from the "ironclad" energy/GNP correlation suddenly crumbled.

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*For example, D. Olivier *et al.*, *op. cit. infra*, show a 9x electricity savings in the U.K. by 2025, with 1980 prices and technologies; A.B. Lovins *et al.*, *Least-Cost Energy: Solving the CO_2 Problem* (Brick House, Andover MA, 1982), an analysis for the German Federal Environmental Agency, show a trebling of West German electrical efficiency (and a quintupling of primary energy efficiency) over about 50 years, with 1980 technologies nearly all cost-effective at 1980 prices; and Prof. T.B. Johansson *et al.*, *I Stället för Kärnkraft: Energi År 2010* (DsI 1983:18, Industridepartementet, Stockholm) show a doubling of Swedish electrical efficiency, with ca. 1982-83 technologies and prices, over several decades. See also SERI, *op. cit. infra*, for a detailed U.S. analysis.

†Many things, such as consumption of Coca-Cola, are *correlated* with GNP, but that doesn't mean that in order to increase GNP everyone must drink more Coke.

This last point deserves special emphasis. No amount of econometric analysis of past behavior can predict the SL light bulb. In fact, there are at least seven good reasons why the electricity/GNP correlation has persisted a decade longer than the energy/GNP correlation, but should not long continue to do so:

- compositional change: an average service-sector worker, for example, uses a quarter as much electricity as an average manufacturing worker, and many of our most electricity-intensive industries are shrinking or moving offshore;
- most electricity-saving technologies, unlike most direct-fuel-saving technologies, are too new to be widely familiar or available;
- most electricity-using devices are specified by HVAC engineers, spec builders, landlords, and others who care about capital but not running costs, whereas most fuel-using devices are bought by end-users concerned with both;
- electricity is more heavily subsidized than direct fuels (marginal nuclear electricity, for example, is at least 70% subsidized*);
- power-plant lead times are so long that it takes decades for marginal costs to work through fully into average prices (much slower than for fuels);
- higher fuel prices hit direct-fuel users with full force, but are diluted by fixed charges when reflected in electric bills; and
- many utilities have, or until lately had, promotional tariffs and programs.

As the lags arising from these artifacts gradually dissolve, I expect electric demand to trend downwards, just as total energy demand has been doing for years. The rate shock soon to hit a third of American households will speed that trend. Rapid economic growth (or, in particular areas, rapid in-migration) will also accelerate gains in electric efficiency, because old, inefficient buildings and equipment will be fixed up, retired, or diluted faster. And the writing is already on the wall: electric demand per house, per commercial customer, and per unit of industrial output has been approximately flat or falling for years.

That is why it is perilous to ignore the engineering evidence of rising electrical productivity in favor of the evangelical theology of the electricity/GNP ratio—as if these two quantities must spiral ever upwards in a frenetic embrace. Of course, there will be new uses for electricity: there will be robots (which, if used throughout the economy, would consume at most hundreds of megawatts), new industrial electric processes, new home video games and computers, perhaps even Woody Allen's "orgasmatrons" (shorthand for the not-yet-thought-of uses prominant in many demand forecasts). But I have seen no quantitative proof —only handwaving assertions—that new uses will make more than a minor dent in the immense savings that are clearly cost-effective in every sector.

Nor is efficiency the only formidable competitor with today's power plants. In the past few years, for example, California utilities have offered to buy privately generated and financed electricity, generally at below full avoided cost. By mid-1984 they had been seriously offered 9.8 GWe of alternative generation, of which 1.2 GWe was online, 4.6 GWe was under contract and construction, and at least 70% was renewable†. These figures exclude utility-owned capacity and joint ventures; including both would raise California's offered and online renewable and other independent-producer capacity to over 20 GWe, or over 55% of peak load. And new offers are coming in from entrepreneurs at the rate of 1.65 GWe per quarter!§ Of course, many small-power ventures are driven by tax preferences; but so are conventional power plants, whose subsidies, broadly speaking, tend to be comparable or larger*.

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*Author's analysis based on tax preferences, deferred costs, and R&D budgets.
†Of the 9.8 GWe, 47% was ca. 50-50 cogeneration and biomass, 36% was wind, 9% small hydro, 5% geothermal, 3% hybrids, and 2% photovoltaic and solar-thermal.
§Imagine how swamped with offers the utilities would have been had they also offered the same price for saved electricity. Even with very limited financial incentives, during 1975-83 California utilities cut forecast peak load growth by four percentage points, and thus saved some 16 GWe of installed capacity.

Few people realize the scope of the renewable energy revolution—in part because the Department of Energy refuses to keep statistics on it. Since 1979, United States energy supply has been increased more by sun, wind, water, and wood than by oil, gas, coal, and uranium (or any of them). More new generating capacity, too, has been ordered from small hydro and windpower than from coal or nuclear plants or both, excluding cancellations. Renewables now provide 9% of total U.S. primary energy, and the fastest-growing part—outpaced only by savings.

By 1 October 1984, FERC permits had been sought for over 14 GWe of dispersed generation—4 GWe of it in the past year—and at least that much appears to be in advanced stages of planning. (In contrast, <1 GWe of central-thermal-station capacity has been ordered since late 1981.) During 1984 alone, cogeneration is rising from 5% to 7% of national generating capacity. Renewable sources account for about a sixth of the cogeneration permit applications and for a far larger fraction of all new energy supplies: for example, counting both electric and useful thermal outputs, the nation now gets twice as much delivered energy from wood as from nuclear power. Windfarms are competing on the grid in at least six states; 2-3 GWe of wind capacity will be online by 1986; and some of the latest wind machines look profitable even without tax credits (which can hardly be said for thermal power plants). Some 7-10% of all 1984 housing starts use passive solar design. About a million solar buildings have been put up in the past five years, most of them passive and many built by people with extremely low incomes.

Among technologies coming fast over the horizon, photovoltaic costs in particular continue to drop and worldwide technological breakthroughs are frequent, although Federal funding cuts have greatly reduced U.S. market dominance. PG&E's director of PVs thinks it will be fairly common by 1990 for houses in her service area to be net exporters of electricity from solar cells on the roof. One vendor already offers turnkey PV installations for $2500/kWp—ca. 10-15¢/kW-h—if anyone will buy 100 MWp, and is selling 2-MWp arrays which appear to be a fine industrial investment. Third-party financing is now available for wind, small hydro, solar water and process heat, cogeneration (from Roger Sant's firm, among others), some photovoltaic systems, and many efficiency improvements; it is the fastest-growing financial vehicle in the energy industry.

So rapid, in short, is the progress in not just developing but actually installing practical, cost-effective renewable sources that it now appears that far from there being too few such sources to run an advanced industrial economy, there will probably be too many. That is, there will probably be attractive renewable sources which will not ultimately find a big market niche, simply because there won't be enough demand to support them all: efficiency will beat all forms of supply. Despite many rearguard attempts to frustrate its intent, PURPA, where given a chance, has succeeded beyond its proponents' dreams—so far, indeed, that the avoided cost has nowhere to go but down*.

As efficiency cuts electrical demand, renewables' share of supply will become dominant. Quadrupled efficiency, other things being equal, would make the old, cheap hydro capacity already online supply not an eighth (as now) but half of all electricity used. The remainder could easily be filled, indeed will probably be overfilled, by a combination of small hydro, cogeneration, wind, and photovoltaics. The power they provide will be firmer than that which we get now from big thermal plants, which will have become uneconomic and unnecessary. Utilities in the 2030s will probably not be manufacturers of a bulk commodity, but rather dispatching and bookkeeping operations mediating between many dispersed sources and many dispersed users. The giant plants which dominate the grid today, by the time they retire, will have become mere historical curiosities[*].

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*Many utilities, however, still offer a derisory buyback price to Qualifying Facilities under PURPA. It would be interesting to see how that offered price would change if they were told that their next plant will be treated as an arm's-length QF: to the extent it works and they can sell its output, they will pay themselves the same avoided cost they offer to others, and to the extent it doesn't work or they can't sell its output, they will pay themselves nothing. Such symmetrical treatment would give utilities the same risks and rewards which private entrepreneurs get, and would therefore result in a more efficient allocation of capital between central plants and small power production.

What does this imply for utility strategy? Because of competition from efficiency and alternative supply, and because of exogenous economic uncertainties, it is common ground that long-term demand for grid electricity is uncertain. The greater the scope for saving electricity, the greater the uncertainty: for example, a 5,000-sector least-cost analysis for Britain[†], based on 1980 technologies and prices, has shown that by 2025 the difference between the official estimate and the least-cost requirement for U.K. generating capacity is a *factor of nine*. If I am even partly right about the even larger savings available from newer technologies, demand uncertainty is far larger than any utility appreciates.

Is the solution to uncertainty, then, to build more thermal power plants so as to ensure adequate electrical supply? Emphatically not, for three reasons:

- The financial risk of misforecasting is too great. For example, the August 1983 report of DOE's $3 million Electricity Policy Project (though effectively disavowed by the Deputy Secretary of Energy[§]) called for building one a big power plant per week starting now, based on forecast demand growth averaging 3%/y, plus or minus one percentage point. But by 2000, that ±1% is equivalent to a quarter of today's entire national generating capacity, with a capital cost of a third of a trillion 1983 dollars. Nobody can afford an "insurance policy" with such a huge premium[¶].
- Construction at high marginal costs heightens the risk that higher prices may reduce the revenues needed to pay for that construction (and, in the shorter run, will exacerbate utilities' inherent instability of cashflow, risking a "spiral of impossibility"[°]). Ironically, a main *cause* of today's uncertainty in demand is the rate volatility caused by *construction*—which was undertaken in a vain effort to hedge against uncertain demand!
- The plethora of decentralized sources, many already competitive and others fast becoming so, will make new big plants obsolete before they're finished.

Escaping from this maze requires rewriting the conventional tenets of utility management. If demand is uncertain, and building plants in self-protection is unaffordably risky, the answer is not to bet still more on becoming able to forecast better; it is rather to *reduce uncertainty and risk to an affordable level*. That is, rather than trying to project demand and build to meet it, the best-managed utilities are seeking to become indifferent to demand—flexible enough to meet it *ad hoc*. Rather than staking survival on any one of many conflicting forecasts, not all of which can be right, successful utility managers seek to become able to accommodate any of them in case it turns out to have been right. Such "management by openfield running" requires that utilities:

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[*] This is as it should be: dozens of neglected diseconomies of scale ensure that for virtually all applications, it is cheaper per kW and per kW-h to build power plants small than to build them big. A.B. & L.H. Lovins, *Brittle Power: Energy Strategy for National Security*, Brick House, Andover MA, 1982, Appendix A.

[†] D. Olivier *et al.*, *Energy-Efficient Futures*, Earth Resources Research Ltd. (258 Pentonville Rd., London N1 9JY), 1983, £42 postpaid airmail.

[§] Energy & Power Subcommittee, Energy & Commerce Committee, U.S. House of Representatives, *Need for New Powerplants*, Serial #98-104, USGPO, Washington DC.

[¶] Modelling by Cazalet *et al.* is often invoked as proof that on the contrary, it's safer to overbuild than underbuild. This result was shown in 1978 to be a spurious result of flaws in the model. See discussion in A.B. Lovins, "Electric Utility Investments: *Excelsior* or Confetti?," 1979 E.F. Hutton conference paper, *J. Bus. Admin.* 12(2):91-114 (Vancouver, 1981), at nn. 47-50.

[°] A.B. & L.H. Lovins, "Electric Utilities: Key to Capitalizing the Energy Transition," *Technol. Forecasting & Social Change* 22:153-166 (1982); A. Ford & A. Polyzou, "Simulating the Spiral of Impossibility in the Electric Utility Industry," LA-UR-81-3343 (1981), Los Alamos National Laboratory.

- reduce the level of demand;
- reduce the uncertainty of demand; and
- reduce the unit cost of hedging against residual uncertainty of demand.

Reducing the level of demand saves two critical resources: money and time. It saves money in three ways: it saves operating costs in the short term (efficiency costs less than fuel plus O&M plus grid losses); it saves construction costs in the medium term; and it saves replacement costs in the long term*. All three savings decrease the present value of revenue requirements. Reducing demand also stretches operating reserves and operating lifetimes, postponing capacity decisions as long as possible so that more information will be available.

Reducing the uncertainty of demand is equally vital. Consider the electricity needed to run, say, refrigerators in 2000. The number of refrigerators is only slightly less certain than population, since the market is highly saturated. But a utility which doesn't know whether its customers will buy 1500- or 25-kW-h/y refrigerators (both are now available) must assume the worst and buy extra, very costly capacity as "insurance." Programs like appliance efficiency rebates, or (at no cost to the utility) Federal or state appliance standards, at least knock the worst refrigerators out of the market and at best actively encourage customers to buy very efficient models. The more they do so—and utility experience now makes their behavior under such incentives fairly predictable—the more potential demand is eliminated and the less hedge must be bought against it.

Reducing the cost of hedging against remaining uncertainty requires utilities to acquire options which are small, modular, and incremental, and which have short lead times, relatively low capital intensity, and high velocity of cashflow. These keys to planning flexibility—buying options which are small, fast, and cheap—are now endorsed by every successful utility manager. Improved end-use efficiency meets these criteria best; central stations, worst; cogeneration and most dispersed renewables, in between† (and better than combustion turbines).

There are many ways in which a utility can encourage and enable its customers to invest in efficiency on their side of the meter: information, example, targeted education of key groups, purging of institutional barriers, truthful prices§, economic incentives, direct financing, and mechanisms for making a market in saved electricity. The appropriate blend and details of each of these instruments will be unique to each utility. I shall discuss here only the last three of them—the financial and market measures a utility can use—because as long as it is cheaper to save electricity than to make it, both utilities and ratepayers can benefit from properly structured utility financial participation in efficiency. After all, a kilowatt-hour saved is just like a kilowatt-hour generated, only cheaper, and can be resold to someone else, so they should be treated alike: utilities should dispatch negative loads, and aggressively market *negawatts*, because they are thereby acquiring the cheapest resources for their system and helping their customers get the cheapest energy services.

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*Avoiding replacement when plants retire, though often ignored, is important because replacment often costs 10-20 times the depreciation now being collected in the rates—but can be foregone if efficiency improvements displace the retiring plant during its operating lifetime.

†Interestingly, ARCO Solar recently put 6.5 MWe of photovoltaics online, starting from scratch, in ten months. Several makers can increase that amount almost indefinitely. With a lead time of months, windfarms can now be installed at a rate of MWe per day. Some utility managers say that it is worth paying a premium for such flexibility (which lets them meet demand as it arises in the short term) and for the smooth, incremental, non-lumpy cashflow needed to finance it.

§By this we mean unsubsidized prices wherein incremental demand attracts its true incremental cost. Rolled-in, subsidized, and declining tariffs signal the wrong price. If people don't know what additional electricity really costs, they won't know how much is enough, and will continue to underinvest in energy productivity. Several ingenious methods for charging marginal cost without accruing excess revenues have recently been proposed.

Many smart utility managers are now using innovative financing concepts. Loans for saving electricity are now commonplace: since I suggested them in 1976-77*, utilities with over half of national generating capacity have begun making them. Few such loans are well structured: most are restricted to a list of approved measures (a list which is incomplete and usually becomes obsolete before the ink is dry), have a fixed and generally short repayment period, and bear low or zero interest requiring cross-subsidy†. Nonetheless, the better loan programs, even though they also tend to promote obsolete technologies, have saved large amounts of electricity at about 1-2¢/kW-h. An even better system—full financing (gifts rather than loans)—is preferred by some utilities, especially in the Northwest and for low-income customers who abhor additional debt on any terms. Participation rates for such consumer-pays-nothing programs have ranged up to 95+%.

Some utilities also buy back saved electricity—in effect, as if it had been generated under PURPA. At least 25 utilities now offer rebates for buying efficient appliances, and thereby save electricity at a cost of 1-2¢/kW-h§. PG&E and Southern California Edison Co. pay respectively $280/kWp and $300/kWp for peak savings achieved by any method. Some SCE incentive programs amount to prepurchasing saved kW-h at a flat rate of 2-4¢ each (far below avoided cost).

In two striking prepurchase initiatives of the Bonneville Power Administration, Snohomish PUD pays 29.2¢/kW-h, and Pacific Power & Light Co. in a Hood River County [Oregon] experiment pays *$1.15/kW-h*, for first-year savings from any durable device. These up-front payments--less than the present value of a 10- to 20-year stream of avoided cost—enable the customer to buy the device that will produce the savings. For example, if I lived in Hood River County and wanted to buy my 23-kW-h/y refrigerator, PP&L would send me a check for more than $1,700. I could use it to buy the refrigerator, throw a party with the balance, and watch my annual bill drop by the value of about 1500 kW-h/y. PP&L's advance purchase of my savings amounts to installing in my house a small, cheap hydro dam which will reliably churn out its negawatts for decades to come.

The most elegant concept for marketing negawatts and demarketing costlier megawatts is for a utility to run a public auction. It would announce its willingness to enter, say, 10-year contracts to pay 1¢/kW-h for electricity made, displaced, or saved by any means. It would accept all bids at that price and place them under contract. It would then raise the offer to 2¢/kW-h and sign up all bidders at that price; then offer 3¢/kW-h, and so on. Somewhere around 3-4¢/kW-h in my opinion, 4-5¢/kW-h in that of some of my more pessimistic colleagues--in any event, at about half of present prices—the utility would have achieved a market-clearing price representing the least-cost balance between all supply options and all efficiency options. New auctions would be held as old contracts rolled over, ensuring that all electrical service needs would be met while enabling improved technologies to lower embedded costs. Several utilities are now considering this method; one even hopes to become the nation's first "negawatt broker," making both spot and futures markets in saved electricity.

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*Actually I understand they were invented earlier, in a different context, by Michigan Consolidated Gas Co., which found it cost less to insulated thousands of house roofs around Detroit than to procure more gas.

†I prefer loans at the utility's cost of money, repaid only out of energy savings so that the borrower needs no capital up front. Since energy savings generally take about a tenth as much capital per watt of delivered service as power plants and pay back about ten times as fast, thus reducing capital needs by up to a hundredfold, many utilities can bootstrap such loans from cash retained earnings, loaning at nearer their embedded than their marginal cost of money.

§PG&E gets the same result at a third the cost by giving salespeople cash rebates for *selling* efficient appliances, but none for selling poor ones—which soon vanish from stocks because there's no incentive to carry them.

Third-party shared-savings financing can give cheap power to industry without cross-subsidy: factories can finance savings by other customers, then buy back the saved kW-h at an arbitrated intermediate price (as is being tried in New Jersey). Shared-savings financing is also simply a profitable venture, at which more than 11,000 energy-service companies are currently succeeding in Europe. Under another exciting concept, a customer could sell the utility, as part of its resource plan, a covenant promising that his or her premises will never use more than x MWe. Such a covenant could even be resold, just as certificates of decrement of air pollution are now marketed under the EPA's "bubble concept." SCE already uses a somewhat similar system--monthly rebates to major industrial customers for each kWp by which they will allow themselves, in rare power emergencies, to be curtailed to a threshold which they themselves choose in advance. The rebate is big enough to give many customers a few years' payback from cogeneration which can provide full backup capacity or even take them off the grid.

I assume here, conservatively, that utilities will follow a short-run avoided-cost criterion of buying all efficiency cheaper than operating the costliest marginal plant in service*. This is simply the principle of economic dispatch: whenever efficiency beats thermal plants in the merit order, it should be dispatched first. Efficiency backs out the costliest plants first, reducing all customers' bills just as a cheaper fuel contract would. The same fixed costs must be paid whether sales go up or down; if fixed costs are spread over smaller sales, electric rates may rise, but energy-service bills will fall. Moreover, major savings are not achieved instantaneously, but over a period ordinarily comparable to the depreciation lifetime of power plants. If sales fall at the same rate at which net plant in service depreciates, fixed charges per kW-h sold will not change. In a practical case, doubled end-use efficiency could typically cut both electric bills and energy-service bills in half while increasing the utility's net for common (in absolute terms) by severalfold via halved operating costs. A utility should not fear reduced revenues, provided costs drop at least as fast; if they drop faster, absolute earnings will thereby increase.

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*Longer-run savings should be counted too. I do not, however, accept the "no-losers" ("hardly-any-winners") test as a sound constraint on utility investments in efficiency, any more than they would accept it as a constraint on supply investments. Such tests limit the price of purchased efficiency to avoided cost minus lost revenue, or to average generation cost, because paying more could increase nonparticipants' rates. Such restrictions result in grossly suboptimal investment which raises everyone's rates and bills, uniformly and perhaps equitably, but unnecessarily. The test is wrong because it focuses on rates, not bills: higher rates need not mean higher bills if offset by lower consumption. Further, to the extent that nonparticipants get costs but not benefits, they have an incentive to become participants and thus go for the benefits too; the unpalatable alternative is to deprive participants of the benefits of least-cost investment opportunities because other customers choose to be less provident. No-losers tests also reflect a basic asymmetry. Historically, nonparticipants in demand growth have had to pay their share of its costs regardless, on the sound economic theory that all users are marginal users: longstanding customers who do not install SL light bulbs are as responsible for marginal demand as is a newcomer wanting a hookup. But on the same principle, nonparticipants in demand shrinkage should have to pay their share of its costs too—provided always that the resource which the utility is acquiring is the cheapest for the system. (In practice, all this may be unimportant because efficiency generally costs less than average price anyhow.)

If that basic criterion is followed--if utilities' mission becomes, not selling more kW-h, but supplying, financing, or facilitating customers' access to least-cost means of obtaining energy services--then utilities can once more become a declining-cost industry, as they were before about 1970--the good old days when regulators' task was to allocate savings, not costs. As old, cheap hydropower comes to dominate supply of greatly reduced national demand, you will have enormous savings--ultimately over $50 billion per year--to allocate. You can and should give a substantial portion of them to investors: utility managers are far more likely to pursue least-cost investment strategies with vigor and imagination if they believe such behavior will gain a higher return. I would therefore urge you to create and fulfil an expectation that sound, successful, entrepreneurial management which cuts effective operating costs will be amply rewarded.

Whatever direct financial incentives a utility offers should be:

- across-the-board (not tied to any list of approved measures);
- flexible (to elicit types of savings not anticipated);
- open-ended (so that the more people save, the more they earn);
- designed to reward people for saving electricity, not for spending money;
- adaptive (to take immediate account of new technologies and methods); and
- consistent (since nobody will believe a utility which says to save electricity this year, use more next year, and save the year after that).

Utility programs--and corresponding regulation--to encourage efficiency should not get stuck on a small number of programs, but try dozens at once in parallel: eliciting and rewarding innovation, taking risks, celebrating failures, and letting a thousand technological and institutional flowers bloom.

Let me now sketch several welcome consequences of encouraging and enabling the utilities and ratepayers in your jurisdictions to do the cheapest things first:

Macroeconomics. U.S. utilities are now spending about a dollar per household per day building uneconomic power plants. In 1982, the U.S. spent twice as much building reactors (most of which won't and none of which should be finished) as it invested in the iron, steel, car, and truck industries combined. Some utilities, relying on their "guaranteed" rate of return--which is paid for by purchases of electricity which are purely voluntary--are selling unsecured Eurodollar notes at 18-21%/y in the Dutch Antilles to pay next quarter's dividends, and even to pay interest on past borrowings. (Why should Citibank go to Argentina to make involuntary loans when it can have the same thrills in Kansas and New Hampshire?) Utilities which are building plants bigger than they are--like being pregnant with a 300-pound baby--have evidently forgotten, as Steve Ferrey reminds us, Miss Piggy's First Law: "Never try to eat more than you can lift."

Such spectacles represent above all a shocking misallocation of capital. Today, with the average short-run marginal cost of a delivered (not installed) nuclear kWe over $9,000 (1984 $), a builder who installs $900-odd worth of electric space- and water-heating equipment in an ordinary tract house in, say, a Chicago climate can thereby commit a typical nuclear utility to spend more than $200,000 on capacity to serve that house--more than twice the entire construction cost of the house! One reason the builder can't then get the next construction loan, or that the buyers can't get mortgages, is that the utility already has the money. Spending a few percent of the utility's offsite costs on superinsulation and simple solar systems could cost-effectively eliminate those space- and water-heating loads--and thereby protect not just ratepayers, but lenders for whom default looms when utility bills start to exceed mortgage payments.

National energy bills today are about $150 billion lower than they would have been at 1973 levels of energy efficiency. Yet if the United States today were as energy-efficient as Western Europe is, our annual national energy bill would be about $200 billion lower still--enough to offset the Federal deficit, or to save an average citizen about $800 per year. By the year 2000, a very detailed

Federal assessment of a least-cost energy strategy showed[*], moreover, that with a two-thirds increase in real GNP, demand both for primary energy and for grid electricity could drop by a quarter, and use of nonrenewable fuels by half, just by selecting the best energy buys. No more power plants would be needed—let alone the trillion 1982 dollars' worth which DOE's Electricity Policy Project said would be required to keep the lights on through the 1990s. The net saving by 2000 would amount to several *trillion* 1984 dollars: enough to pay off the entire National Debt. The reallocation of investment needed to win that tempting prize has already begun. In 1980 alone, Americans spent about $6 billion on renewables and $9 billion on efficiency—a fifth of all energy investment—and those figures have undoubtedly risen since. You as utility regulators can speed that trend by requiring rigorous proof in advance that utilities are pursuing what Roger Sant calls a "least-cost energy strategy"—best buys first.

Incidentally, least-cost investment, by leading to a more efficient, diverse, dispersed, renewable energy system, would also dramatically reduce (and could even eliminate) the likelihood of major blackouts, thus making an important contribution to national security[†]. And investing in the best ways to save oil[§] would relieve oil dependence far more effectively than power plants ever could. Indeed, building power plants to displace oil-fired electricity actually *retards* energy independence, because the dollars it devours cannot be spent on end-use efficiency, which saves both directly used oil and oil-fired electricity far faster and cheaper than power-plant construction can.

Acid rain. Building on a least-cost analysis of the "greenhouse effect,"[¶] Eric Miller (a Dartmouth College graduate student) and I have been exploring a least-cost way to abate acid rain. In brief, instead of raising electric rates to put costly scrubbers on dirty coal plants, one could install superefficient lights, motors, and appliances; use less electricity; burn less coal; emit less sulfur; and *lower* rates, because efficiency costs less than coal. Part of the stream of savings could then additionally be used to finance any combination of stack-gas cleanup, fluidized-bed conversion, and fuel-switching to achieve a further, larger sulfur reduction—still at negative net cost. Happily, the same technologies which achieve this in (say) the Midwest are exactly the ones needed to bail out the utilities mired in Marble Hill, Zimmer, Midland, Clinton, etc.

Abandonments. In nonconfrontational, unrebutted testimony to and for the Maine PUC on 1 October 1984[°], and in testimony for the New Hampshire Consumer Advocate to be defended shortly before the NHPUC[°°], I detailed how to abandon Seabrook *with no losers:* that is, how a market-oriented program to provide electrical services at least cost can make it unnecessary and uneconomic to complete the plant, can generate a stream of savings to pay off its sunk costs, can maintain reliable service, and at the same time can significantly cut customers' bills.

My testimony showed how to save far more electricity than Seabrook could make, at less than the cost of *operating* it, and with improved reliability. Naturally, with at least $1.5 billion in completion costs *not* yet sunk, the net benefits of abandonment are even larger than saved operating costs. Substituting efficiency for Seabrook's completion *and* operating costs would save (as Table 1 shows) some $5.3-11.4 billion in 1984 net present value. That is enough to repay all the investors' sunk costs (about $3.3 billion in 1984 $ including AFUDC), even with a return, while *lowering* the rates and hence making PSNH's overpriced power more competitive. Both to meet energy-service needs and to generate cashflow for amortization of sunk costs, efficiency must grow by at most a few percent per year—the rate at which Americans have routinely been saving energy for a decade with little real assistance. Similarly, investments in efficiency, rather than being compressed into a few hectic years of construction, are spread smoothly over decades, paying for themselves as they go: their lifecycle cost is at least 13-26 times less than that of Seabrook, their peak cashflow need >10x smaller.

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[*] Solar Energy Research Institute (SERI), *A New Prosperity*, Brick House, Andover MA, 1981.

[†] See Lovins & Lovins, *Brittle Power*, *op. cit. supra*.

[§] Weatherizing buildings and speeding the replacement of gas-guzzlers by more efficient cars could each save over 5 million bbl/d @ <$5/bbl (*id.*).

[¶] See A.B. Lovins *et al.*, *Least-Cost Energy*, *op. cit. supra*.

[°] Docket #84-113 (Seabrook Investigation), Exhibit PUC-13.

[°°] Docket #84-200 ("Newbrook" Investigation), Exhibit ___.

Seabrook is but the overture to a far larger drama to be played out on the U.S. and world stage over the next few decades. Already, some $25 billion in nuclear plants (plus many billions of dollars' worth of other plants) have been abandoned, with another $30-40 billion on the brink. The no-losers approach applies as well to these troubled projects. It avoids the traditional and rancorous dispute between ratepayers and investors—a dispute which too often keeps utilities nibbling at the bullet of abandonment until it is too late to escape unbloodied. Yet since a cooperative, no-losers approach (even if not adopted until the eleventh hour) pays off sunk costs from new savings rather than from rate hikes, Commissions can afford to stipulate swiftly a generous level of recovery—rather than spending years (and millions of dollars and much nervous energy) tediously second-guessing exactly how much of the sunk investment was prudently made.

Indeed, Commissions could even provide "incentive recovery," allowing utilities to keep half of the savings they generate (up to a total comprising recovered sunk costs, plus a return, plus a reward for entrepreneurship) while ratepayers took the other half as current rate reductions. This approach is equitable, is politically transparent and easy to explain, and gives the utilities a strong incentive actually to achieve the savings. For the utility—an entity which is, after all, not just a balance sheet but a collection of skilled and dedicated people with a long and honorable tradition of public service—being given a mission it can do well, that needs doing, and that it can feel good about doing is vital to its effectiveness during a turbulent transition. Most utilities, given such responsibility, will rise to the occasion. This will not only get the job done but also preserve their morale and enhance their employees' sense of self-worth, which are assets as vital to society as any technical skills.

Conclusion. We live in an age of costly electricity and cheap efficiency. Utilities which learn how to sell more efficiency and less electricity will prosper. Utilities which try to keep selling more electricity and less efficiency will disappear. The efficiency revolution can be a threat to utilities—quietly destroying their sales and pricing them ever further out of the market—or it can be an unprecedented opportunity for them to reduce risks, improve cashflow and coverage, multiply earnings by severalfold, secure a long-term market share, and enhance their popularity.

Given the increasing availability of cheap ways to save electricity, dramatic efficiency improvements will happen with or without the utilities' blessing and comprehension. Their choice is between participation and obsolescence. Utilities which anticipate, and wholeheartedly participate in, the efficiency revolution will not only enjoy better foresight in and control of electrical markets; they will also become able to lower their prices and enjoy handsome returns, making money by slashing their operating costs and perhaps also as bankers marketing a financial product which earns them a spread.

Accordingly, to help ratepayers get reliable service at least cost while utilities make more money at less risk, regulators' challenge is to help remove utilities' barriers to market exit from what is no longer a commercially viable enterprise—generating and selling electricity from large thermal power stations—and help instead to speed their entry as effective, efficient competitors in the emerging energy-service marketplace.

Table 1

Three Estimates of Levelized Marginal Savings from Abandoning Seabrook I

In general, the CONSERVATIVE case reflects PSNH's assumptions: $1.5b completion cost (1984 $ including AFUDC), 70% capacity factor, 40-y lifetime, low operating costs. The REALISTIC assumptions use mainly empirical best-fit data, such as NERA's expected marginal completion cost ($1.7b), 55% capacity factor, 30-y lifetime, Elk River decommissioning data, 3%/y real escalation of net capital additions for years 1-20, and (optimistically) no real escalation for O&M costs. The PLAUSIBLY DISAGREEABLE assumptions, though not a worst case, are generally a standard deviation worse than average—NERA's high cost estimate ($3.3b), 37% capacity factor, 25-y lifetime, Shippingport decommissioning data—and use empirical real escalation of 5.7 %/y and 2.9%/y respectively for net capital additions and O&M in years 1 to 15. The nominal fixed charge rates assumed are respectively 15, 17.6, and 19%/y levelized. For details, please see Lovins testimony, NHPUC #84-200.

PRESENT-VALUED NOMINAL 1984 ¢/kW-h DELIVERED TO FINAL USERS

CASE:	CONSERVATIVE	REALISTIC	PLAUSIBLY DISAGREEABLE
capital charge to complete	3.2¢/kW-h	5.4	16.8
current op. costs: fuel-cycle	1.1	1.1	1.2
O&M	1.0	1.3	1.8
prop. tax & ins.	0.2	0.3	0.4
future op. costs: decommissioning	0.02	0.1	0.5
net cap. addns.	0.3	1.2	1.2
grid losses in delivering output	0.2	0.2	0.3
GROSS SAVING FROM ABANDONMENT	6.0¢/kW-h	9.6¢/kW-h	22.2¢/kW-h
less cost of 1150 installed MWe of end-use efficiency	(2.0)	(1.8)	(1.5)
NET SAVING FROM ABANDONMENT	4.0¢/kW-h	7.8¢/kW-h	20.7¢/kW-h
restated as undiscounted total over plant's operating life	$10.8b	$12.3b	$18.2b
same discounted to present value	$ 5.3b	$ 7.1b	$11.4b

CONCLUSIONS:

1) All present-valued net savings are positive—i.e., completing and operating Seabrook costs more than efficiency to do the same tasks.
2) Cancelling Seabrook, even after $3.3 billion has been sunk in it, and buying efficiency instead is an advantageous exchange.
3) The net benefit of that action is large enough to pay off Seabrook's sunk costs while paying a return on those sunk costs, or substantially lowering the rates, or both.

UTILITY RESOURCE PLANNING: THE STATE OF NEVADA ADOPTS AN INTEGRATED PLANNING MODEL

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UTILITY RESOURCE PLANNING: THE STATE OF NEVADA ADOPTS AN INTEGRATED PLANNING MODEL

Introduction

Not all "new wave" activities have been the sole province of the music industry. On a less flamboyant scale, the State of Nevada has its own "new wave" movement of sorts; changing the way electric utilities evaluate and plan for future energy needs.

The 1983 session of the Nevada Legislature passed into law Senate Bill 161, the Utility Resource Planning Act. Authored by the state's recently created Office of Consumer Advocate, the legislation is a bold step on the road to insuring that the state's electric utilities employ accurate forecasts of their future energy needs and that those future needs are fulfilled using the most practical and cost effective means.

The cornerstone of the legislation requires electric utilities to submit to the Nevada Public Service Commission every two years a fully integrated, long-range resource plan which must demonstrate that all aspects of a utility's future energy needs have been considered.

Under the Act's provisions, demand and supply functions must be evaluated in a dynamic, iterative process that considers risk, sensitivity and uncertainty factors. The end result will be an integrated "least cost" resource plan. As a further step to total procedural integration, before a utility can receive permission to go forward with the construction of a new generation facility or major transmission line, the proposed project must be part of the "least cost mix" in a previously approved resource plan.

Regulations promulgated pursuant to the Act require five areas of major analysis in the plan filings:

1) Forecast of future demands;

2) Assessment of demand options, i.e., conservation and load management potential;

3) Assessment of supply options;

4) Integration of demand and supply;

5) Two year implementation plan.

Both the legislation, and the regulations enacted by the Nevada Public Service Commission to implement the Act form the framework for a truly integrated resource planning process. The entire process hinges on the simple economic principle of utilizing the least cost means to meet future electrical energy demands for Nevada. These economic principles were first considered for implementation by this Nation's electric utilities in Amory Lovin's paper "Energy Strategies: The Road Not Taken" for _Foreign Affairs_ and later described in more extensive detail in his book *Soft Energy Paths*.[1] Based in part on the theories of Lovins and others, recent literature in the field of public utilities discusses an emerging public policy awareness that a least-cost energy strategy could make good business sense for electric utilities. "The first step to implementing such a strategy is a shift in focus from selling electricity to selling energy services."[2] The Consumer Advocate's Office believes that an integrated least cost planning process, as described below, is the tool by which utility managers will begin to perceive themselves as providers of least cost energy services. Such a refocusing will benefit Nevada ratepayers by stabilizing future energy costs, and assist Nevada's utilities by lowering capital requirements. We do recognize that the process we are about to describe may not provide a total solution to meeting the electrical energy requirements of this Nation. To succeed and work effectively, such an integrated resource planning process may need to be coupled with innovative rate design proposals such as those recently implemented in Oklahoma[3] Regulatory commissions should be cautious, however, that rate design proposals are truely complimentary to least cost resource planning. Some rate design strategies may masquerade as options which will reduce long run capital costs, but in reality result in the building of base load requirements.

Nevada's resource planning process may not appear uniquely inherent to Nevada given the extensive history of resource planning activities in several other jurisdictions such as the Pacific Northwest, California and Wisconsin. Nevada's planning process is unique and innovative, however, and goes beyond past activities in other states. This paper will explain and demonstrate the distinctions between the efforts in other states and compare them to the resource planning model being implemented in Nevada. The aspects of the Nevada process which are fully discussed herein include the major components necessary for integrated resource planning, Nevada's resource planning approach, and contrasts and comparisons to the other jurisdictions. The paper will also describe the policy implications of integrated resource planning for Nevada's electric utility industry in the future.

Integration Begins

Various aspects of integrated resource planning are being implemented by utilities, regulatory commissions and state legislatures throughout the country. A close examination of current state resource planning practices, however, shows that many states are succumbing to a disaggregated approach to resource planning, both procedurally and substantively. A brief survey of these varied approaches and their inherent dangers to the resource planning process is discussed in the following section of this paper.

To set the stage for our analysis of resource planning activities in other states, it would first be helpful to outline our concept of an integrated resource planning process. The Office of Consumer Advocate believes comprehensive statutes and regulations which establish a total integrated utility resource planning approach must contain the following components:

1) PLANNING PROCESS INTEGRATION: Integration involves two aspects; substanc and procedure. Substantively, integration must include a forecast o future demand and a comprehensive analysis of demand and supply option

available to meet or alter demand which are then unified to derive the "least cost" resource plan. On a procedural level, regulators must strive for integration of utility ratemaking and utility construction permit proceedings with the resource planning process to ensure that the new process actually takes hold and leads to long-term economic benefits to ratepayers and financial health for the utility.

2) SUFFICIENT METHODOLOGICAL SPECIFICATION: Such specification of the methodology and models to be used by the utilities is necessary to ensure: 1) state-of-the-art approaches are being employed, 2) there is consistency between different utility plan filings and plan filings over time, and 3) the establishment of a systematic review process for interested parties and regulators. This methodological specification must not be so rigorous, however, as to thwart innovation by utility resource planning staffs and permit flexibility where appropriate.

3) REQUIRED IMPLEMENTATION: Integrated planning must be accompanied by integrated acquisition and implementation of least cost resources. The resource planning process must require the submission of an action plan for regulatory review detailing the means by which the utility plans to acquire and implement resources with cost-effectiveness being the key priority.

4) UTILITY RESPONSIBILITY FOR PLAN CREATION: If integrated demand and supply planning is to be internalized by investor-owned utilities, the expertise and data for plan development must originate from within. This increases the likelihood that the utilities will stand behind their plans and use them in a variety of internal and external decision making processes. By placing primary responsibility for creation and coordination of plan components within the individual utilities successful plan implementation is more readily assured.

5) PLAN ENFORCEMENT: Unless the regulatory process provides for an effective enforcement mechanism to ensure that the utility adequately conducts the planning process, and follows through with acquisition and implementation of plan resources, the entire process becomes little more than an empty exercise. Procedural integration of the planning process can greatly facilitate enforcement of the planning process.

Several jurisdictions incorporate some of these five resource planning objectives; most notably the Pacific Northwest, California, Florida, New York, Ohio and Wisconsin. None of these jurisdictions to date, however, appear to have adopted as comprehensive a resource planning process as Nevada. Each jurisdiction is discussed below.

The Pacific Northwest

The Northwest Conservation and Electric Power Plan was issued April 27, 1983 pursuant to the Pacific Northwest Electric Power Planning and Conservation Act of 1980. The Act establishes the Northwest Power Planning Council comprised of eight members, two each from the states of Idaho, Montana, Oregon and Washington. The Council in part, is authorized "...to achieve cost-effective conservation, to encourage the development of renewable resources, The Northwest Plan was utilized in part by the Office of Consumer Advocate and the Nevada Commission as a reference and guide in the development of Nevada's statute and regulations. Major similarities between the requirements of the two sets of regulations can be seen throughout. For example, both require the development of a range of forecasts to assess sensitivity and risk of resource options to demand uncertainty. Also, both require the development of two-year implementation plans.

Despite the noted similarities, the Northwest Plan fails to meet two of the five objectives, responsibility and enforcement, as specified above to establish an integrated resource planning approach. The failure to meet these two objectives hinges on the fact that the Northwest Plan is developed on an aggregated, regional basis. The plan is not tailored to the unique characteristics of individual utilities. Thus, the fourth objective, responsibility, is not met as the burden of plan development rests with the Council, not the utilities. Therefore, utilities could possibly fail to develop the expertise and integrity needed in resource planning. The fifth objective, enforcement, is not met as the Council has limited powers in this area. Bonneville Power Administration and the other utilities can seek exemption to components of the Plan's requirements, specifically the model conservation standards. If adopted throughout the Northwest, the standards could save the region from two to four coal plants. Unfortunately, most of the region's major utilities have failed to sign long-term conservation contracts with the Bonneville Power Administration. As of September 1984, the City of Tacoma was the only region to adopt the standards. Such actions limit the effectiveness of regional planning overall. A preliminary study by the Council places a $200 million price tag on the cost of delaying the model conservation standards just two years.[5] Utilities found in non-compliance by January 1, 1986 could incur a ten percent surcharge on firm power purchased from Bonneville Power Administration. The surcharge, while meant to encourage conservation incentives, would have minimal effect on customers receiving electricity from utilities buying little or no BPA power, such as Idaho Power.

Thus, in the Pacific Northwest a process has been established for the region as a whole where on a substantive basis the resource planning regulations under the Act are fairly sound and comprehensive. Unfortunately, the integrated process could fall apart both substantively and procedurally when acted on by BPA and private utilities.

Possibly it is still too early to tell whether its "loose linkage" approach will create substantial hurdles to the acquisition and implementation of integrated, least-cost options. The recent Council study does contend that delay in the model conservation standards would prove costly to the region. While failure to participate by these utilities does not signal the failure of the entire Pacific Northwest resource planning process, it does suggest a high level of risk and uncertainty in the success of the plan due to the lack of utility responsibility and enforcement.

California

The State of California has two state agencies actively involved in utility regulation, the California Energy Commission (CEC) and the California Public Utilities Commission (CPUC). In general, CEC is responsible for regulating utility long-range actions such as resource planning. The CPUC is responsible for regulating utility short-term actions such as general rate cases and current conservation programs.

The 1975 Warren-Alquist State Energy Resources Conservation and Development Act in part establishes a state policy "...to employ a range of measures to reduce wasteful, uneconomical and unnecessary uses of energy..."[6] The Act requires the CEC to prepare and submit to the governor and the legislature a biennial report assessing current and future energy trends in California and a state energy policy with recommendations for its implementation. In developing their initial reports, the CEC requires the utilities to submit long-range supply and demand analysis pursuant to a "Forms and Instructions" procedure which sets forth a series of tables, charts and forms to be utilized.

California's landmark process lacks several of the objectives established as necessary to insure least-cost resource planning and acquisition. First, the process is not fully integrated on two levels; substance and procedure. Substantively, the CEC required submittals does not specify that the utilities develop a "least cost" plan. Procedurally, there is no formal integration of the CEC filings into general rate case proceedings before the CPUC. Therefore, the potential exists for important information to fall between CEC and CPUC regulatory "cracks". For example, in a recent case before the CPUC, Southern California Edison was granted a permit to construct a 200 MW hydro generation facility, Balsam Meadows. Due to lack of funds, the CEC did not intervene in the proceedings. If they had, the CEC would have argued against the project, based on need, cost and availability of other alternatives.[7] Second, there is no implementation process in the CEC required filings to ensure "least cost" options are actually pursued and developed. Third, the primary responsibility of plan development does not rest with the utilities but with the CEC. While the utilities face certain filing requirements with the CEC, oftentimes parts of these required submissions are not completed.[8] The CEC at it's own discretion can prepare a different demand and supply forecast for submission to the governor. Fourth, there is no clear power of enforcement. Construction permits are not denied because of a utility's failure to submit the required information to the CEC or based upon analysis by the CEC.

Thus, in California there is established a process that substantively contains many of the components of an integrated resource planning approach but fails to go the full distance needed by not requiring "least cost" plans, implementation plans, enforcement, or placing the responsibility of development more squarely on the utilities.

Recent discussions with the Staff of the California PUC indicate the Commission is moving away from an integrated resource planning approach.[9] From these discussions it appears the Commission has adopted an "avoided cost" philosophy to the issuance of permits for new electric generating facilities. That philosophy would authorize a permit to construct a new generating facility proposed by a utility with the caveat that the utility would only be paid its "avoided cost" for energy from the facility at the time it comes on line. Space does not permit a complete critique of this new process. A cursory analysis seems to suggest, however, that pinning all resource planning on an "avoided cost" concept will lead to either no plant construction and the possibility of capacity shortages or a post facto resource planning process at the time a plant comes on line and an ad hoc determination of the relationship of "avoided costs" to forego conservation and load management opportunities.

Florida

The 1980 Florida Energy Efficiency and Conservation Act requires "...increasing the efficiency of the electric and natural gas systems of Florida and the end uses of these sources of energy..."[10] The Public Service Commission's regulations adopted pursuant to the Act require the utilities to "Review and revise utility operating practices... plan development of the bulk power system... increase the efficiency of existing generating units... aggressively integrate nontraditional sources of power generation... and increase efficiency of transmission and distribution systems...[11] The Act also requires that the Commission consider the length of experience of the utility pursuant to these regulations in any requests for increased capacity under the Florida Electrical Power Plant Siting Act. The Act establishes a 5-year goal beginning January 1981 of an approximate 25% reduction for all electric utilities in peak demand and energy consumption (i.e. to reduce the use of oil by 25%)

Florida's resource planning process operates by the Commission establishing goals which the utilities must then meet. In many ways Florida has been successful with this approach. In an apparent increasing spirit of cooperation Florida utilities are voluntarily proposing major conservation and load management programs. This seems to be producing desirable short term results given that no utilities are proposing construction of new generating facilities even with Florida's high population growth rate. However, Florida's statutes and regulations cannot be construed as establishing an integrated resource planning process. No "least cost" plan is required nor is an implementation plan required. The utilities do not assess the optimal level of conservation potential, but rather work under Commission established goals. Nor is there an enforceable regulatory connection between resource planning and construction permit proceedings. Even though the Florida process seems to have worked well to date, it appears to have done so primarily because of the commitment of people involved in the process rather than the structure of the statute and companion regulations.

New York

The 1976 State Energy Law establishes a state energy office to work with other state agencies in the development and coordination of an overall state energy program. Members of the New York power pool are required to prepare annually a single comprehensive long-range forecast of future demand, future generation facilities, anticipated expenditures for research in conservation load management, electric generation and transmission.[12] The State Energy Office conducts a series of hearings on the utilities' composite filing and prepares a report of the long-range electric and gas demand and supply requirements in the state.

The Public Service Commission is required to review the plan and make two major determinations: 1) whether the proposed plan is cost-effective, and 2) whether the plan will result in significant energy savings. Further, the Commission must give consideration to the plan with respect to any determination of need for a facility.

A recent Commission decision has established a major new energy conservation policy requiring each of the state's electric utilities to take steps to place energy conservation on equal footing with power plant construction and alternate forms of electric generation.[13] The utilities have been directed to commit portions of annual revenues to the development of comprehensive energy plans.

Despite these commendable efforts, the New York resource planning requirements under the State Energy Law and the recent Commission requirements to develop individual utility conservation plans do not represent a fully integrated approach. Neither process requires the utilities to develop individual integrated "least-cost" plans. While the Commission must consider the utilities' composite plan in construction permit proceedings, the State Energy Law does not contain provisions for construction permit denial based on inadequate conservation assessment plans.

Ohio

1983 legislation requires every major gas and electric utility to submit to the Office of Planning and Forecasts (formerly the Department of Energy now merged with the Department of Development), a report which includes a long-range forecast and general description of planned resources. The Office is then required to determine whether the forecasts are based on substantially accurate information and methodology, whether load reductions from energy conservation are considered in the forecast and whether alternatives to meet demand and expansion of the regional power grid was also considered.[14]

Substantively, the primary emphasis is on demand forecasting with very little attention given to supply option analysis. Procedurally, the process is bifurcated in several directions. The Office of Planning and Forecasts is responsible for reviewing the demand portion of the filings, with the Power Siting Board (a separate State agency) responsible for reviewing the supply portion. The Public Service Commission's role in the process is not defined in the Statute or regulations. The Ohio process further fails to represent an integrated approach by establishing no implementation process, specification of methodology or models, or power of enforcement in rate case and construction permit proceedings.

Wisconsin

The 1975 Wisconsin Power Plant Siting Law and implementing regulations of the PSC require each electric utility to file an "Advance Plan" for construction of facilities. The biannual filing must include a long-range demand forecast, plans for the construction of proposed generating and transmission facilities, and an analysis of alternatives to the proposed generation and transmission facilities.[15]

The resource planning process in Wisconsin has evolved over the last several years to a degree where the current planning process is comparable to that which is being established for Nevada. However, the existing state legislation and implementing regulations are more attuned to supply side analysis for power plant siting and do not specifically address the need for conservation potential assessment, integration of demand and supply to derive a "least cost" plan, specification of methodologies or models, or requirements to develop implementation plans. These problem areas are evident in Wisconsin utility plan filings as reviewed by the authors which do not consider conservation as a viable supply resource. Furthermore, conservation potential and cost/benefit calculations were not provided in the plans reviewed. Thus, full integration of demand and supply side resource options appears not to have been completely accomplished in Wisconsin.

Texas

Texas has recently begun their own resource planning process. 198 amendments to the Public Utility Regulatory Act of the Public Utility Commission of Texas under "Article III. Jurisdiction" requires the commission t develop a long-term statewide electrical energy forecast sent to the governo biennially.[16] The forecast must include an assessment of how alternative energ sources, conservation and load management will meet the state's electricit needs. The commission's report is to be derived from reports prepared by th utilities. The Texas Statute and Commission substantive rules go a long way t developing an integrated resource planning process for the State of Texas. Unfortunately, many of the various components believed necessary by the author are not clearly specified in either the law or rule. For example, only the la discusses the need to assess future demand needs, supply options and conservation measures. The commission's rule addresses only the development of energ efficiency plans.[17] Substantively, the Statute does not specify that the utilities or the commission are to derive a "least-cost resource plan". Specification is also not provided as to whether or not the utilities in their assessme of conservation measures are required to determine the cost-effective potentia on a system-wide basis.

Procedurally, at the time of utility application for plant certificatio the utility must set out alternative methods considered, including the exte achievements through its energy efficiency plan have offset the need for ne generation.

It is unclear, however, the degree to which this procedure will enforce t acquisition of least-cost resources or act, merely as a post facto resour planning process.

Oklahoma

Oklahoma's resource planning strategy focuses on a new innovative rate design policy which varies services and prices in ways that are designed to mee specific needs of the individual customer.[18] Dubbed the "New Direction Program", the goal is to reflect elements of competitive pricing and give attention to the marketplace. By "cost-basing" rates, the program will hopefully promote conservation and energy efficiency as a means of lowering future generating capacity requirements. The authors would again caution the need to ensure that rate design proposals are truely complimentary to least cost resource planning.

The Nevada Integrated Model

The Nevada Consumer Advocate's approach to the development of an integrated resource planning for our state's major electric utilities has been an evolving process. Beginning with the creation of the Consumer Advocate's Office in June 1981, the office has argued the need for Commission review, critique and direction on various aspects of utility demand and supply functions in numerous general rate cases and regulatory proceedings. A number of successes have been recorded on these fronts in Nevada in terms of solving some of the problems contributing to the cycle of ever increasing utility rates. However, these changes only represented bits and pieces of a true integrated resource planning approach. None have gone to the heart of the matter, i.e., establishing an integrated planning process to assure that all increases in the cost of utility rate base to meet increased electrical demand are achieved through the selection of least cost options. Recognizing the changes in the long-run incremental cost to utilities over the last decade, the Consumer Advocate's Office determined that the only way to effectively pursue least-cost means to meet future electrical demand was through the passage of legislation establishing an integrated resource planning process.

The Utility Resource Planning Act - The Need

As a first step to integrated resource planning, we drafted the Utility Resource Planning Act and submitted it to the the Nevada Legislature in 1983.

Throughout the legislative session extensive hearings were held. In these hearings our office argued that the commitment of utility capital for the needs of future service demands was the single most important financial decision faced by a utility system in meeting its obligation to provide adequate service.

We further argued that existing law did not provide for any systematic or on-going review of utility resource planning activities. Even though Nevada law did require utility companies to provide such information when they applied for a permit to construct a new generating facility or when they requested that the facility be put into rate base, such review was cursory and inadequate. Furthermore, and most importantly, both of these reviews came after a lengthy planning process and commitment of resources by the utility with no public input or Commission review. By the time a utility filed with the Nevada Commission request for a permit to construct, as much as 10% of the total construction costs may have already been invested. These expenditures could be made over a period of five to ten years in corporate planning, site selection and research and evaluation of the project in question. Historically, PSCN construction permit proceedings were held after a utility had finalized supply resource planning decisions and the proceedings were not designed for detailed review of the economic costs and benefits of alternate supply resources.

The Utility Resource Planning Act broke this cycle by establishing a process where Nevada's major electric utilities must submit to the Commission long-range resource plans for review and evaluation of resource options to meet future supply needs at the least possible cost to the utilities' ratepayers.

The Utility Resource Planning Act - Its Provisions

The Act addresses four of the five objectives previously specified by the authors as necessary to evoke an integrated resource planning approach. The one objective that was not addressed, implementation, was incorporated in the Commission's enabling regulations.

In terms of planning process integration, the Act requires every major electric utility to submit every two years to the Commission "... a plan to increase its supply of electricity or decrease the demands made on its system by its customers. . . ". The plans must show ". . . adequate consideration of the following possible measures and sources of supply; conservation, load management, pooling of power, purchases of power from neighboring states or countries, facilities which operate on solar or geothermal energy or wind, and facilities which operate on the principal of cogeneration or hydrogeneration."[19]

In terms of methodological specification, the Act requires that the Commission to draft regulations specify how the utilities are to develop a "forecast of future demands; and determine the best combination of sources of supply to meet the demands or the best method to reduce them." The Commission must determine that "the utility's forecast requirements are based on substantially accurate data and an adequate method of forecasting."[20]

In terms of responsibility for plan creation, it is the utilities' burden to develop and submit plans.

In terms of plan enforcement, the Commission must hold hearing and accept or reject the components of the plan analyses and the mix of future resources determined by the utility to comprise the "least cost" plan. Commission acceptance of a utility's plan does not signify Commission approval to construct any specific facility merely from its inclusion in the "least cost" plan. The utility must still file under a separate Commission proceeding process for a permit to construct. The legislation links together the two processes by amending a portion of existing state law concerning the Commission's approval process for the construction of a new utility facility. The legislation provides that before a permit to construct a new generating or transmission facility is granted, the proposed facility must be part of a utility's approved resource plan. Thus, no new generating or transmission facilities can be constructed in Nevada unless the facility has been demonstrated at hearing to be an integral part of a least cost resource plan.

General Order Number 43

The regulatory process to develop rules implementing the Utility Resource Planning Act encompassed approximately six months, during which numerous Commission workshops and hearings were held. The final regulation was approved by the Nevada Legislative Council Bureau on June 29, 1984 and totals 41 pages. The regulation contains the following major provisions:

1) Load Forecasting

   a. Requires a 20-year forecast of future demand, a 10-year record of historical demand; by energy, peak demand and reserve requirements.

   b. Requires that a plausible range of forecasts; high, medium and low be developed with the medium to represent the utility's estimate of the most likely set of future events. The high and low forecasts are to be utilized in the evaluation of the sensitivity and risk of supply option scenarios to varying levels of future demand.

   c. Requires the utilization of an end-use methodology in forecasting future demand for the residential and commercial classes. Requires the industrial sector forecast to be disaggregated to the level of two-digit Standard Industrial Classification (SIC) codes.

2) Consideration of Conservation and Load Management.

   a. Requires that price-induced demand reductions and reductions in demand from continuation of current utility and government-sponsored conservation and load management programs be explicitly accounted for in demand forecast.

   b. Requires that energy and demand savings through new utility-sponsored conservation and load management programs be evaluated on three progressive levels; base case, technically feasible and cost-effective.

   c. Requires the design of an implementation plan for selected cost effective conservation and load management measures.

3) Consideration of Supply Options.

   a. Requires that a wide range of resources available to meet future supply needs be evaluated, including, improved utilization and optimization of existing supply resources including: power pooling, power purchases and exchanges of power, and alternate fuel sources such as wind, solar and geothermal.

   b. Requires that minimization of the present worth of future revenue requirements form the basic criteria used to select and prioritize supply options.

c. Requires the utilization of the minimum following sets of models or methods for analysis:

   1. A screening model or method.
   2. A production costing and reliability model.
   3. An engineering economics model or method.
   4. A risk analysis model or method.
   5. A corporate financial model.
   6. A model for integrating the previous models and methods.

4) Integration of Demand and Supply.

   a. Requires integration of the conservation and load forecast options on the demand-side with the resource options on the supply side to derive the "least cost" resource plan.

   b. Requires the use of the integrated analysis for the basis of the resource plan.

5) Sensitivity and Risk Assessment.

   a. Requires sensitivity analysis and risk analysis methods for the assessment of all major assumptions and estimates used in the plans.

6) Two-Year Action Plan. (This implementation requirement completes the five components earlier stated by the authors as necessary for a total integrated process.)

   a. Requires the utilities to submit a plan to implement the "least-cost" resource plan. The two-year action plan must implement those resources in order of cost-effectiveness.

   b. Requires specification of all new and existing utility resources, including models, data, equipment, personnel and facilities which the utility intends to acquire for the development of the next resource plan.

   c. Allows for amendments in the two-year action plans in recognition of the potential for new developments or other reasons to revise planning actions if received within 180 days of the plan filing.

Regulations Translated to Action.

Nevada's two major electric utilities, Nevada Power Company and Sierra Pacific Power Company submitted to the Commission their first Plans pursuant to the 1983 Act on July 1, 1984. Hearings were held the latter part of August, first part of September, with a Commission decision rendered in mid-October

1984.

Several events transpired during the hearing process noteworthy of mention. First, the Office of Consumer Advocate and Commission Staff were able to develop unified positions on major issues such as load forecasting, conservation assessment and supply option analysis. This eliminated competition for position supremacy between intervenors, working to clarify and strengthen the issues before the Commission. Second, both utilities entered into stipulations with the Office of Consumer Advocate and Commission Staff on major substantive issues such as approved base case forecast, additional analyses for conservation assessment, development of conservation implementation strategies, and additional supply option studies. This allowed the parties to avoid many days of adversarial hearings. The Office of Consumer Advocate believes this proved extremely beneficial to all involved: intervenors' goals on major issues were achieved, and the utilities were able to avoid the development of a defensive posture on intervenor positions. All parties, including the Commission, achieved the sought-after goal: implementation of a least-cost resource planning process for the State of Nevada.

While the Commission's October decision approved the Plans of both utilities and offered praise for their hard work in these initial filings, the Commission determined that many critical questions, analyses, and issues were left unfinished. In fact, both utilities recognized this in their filings by requesting numerous exemptions to the regulations. Though granted, the Commission noted that the regulations provide no exemption provision for subsequent filings with full utility compliance expected by 1986. Both utilities were further required by the Commission to file by mid-April 1985 revised two-year action plans containing the various revisions, updates and additional studies specified in the stipulations and Commission decisions. A series of informal workshops and designated reporting requirements have been established for the interim period to ensure that the revised two-year action plans are being developed according to stipulation and decision specifications.

The Office of Consumer Advocate believes much work still lies ahead in achieving a "least-cost mix" of future resources. The initial analyses by both Nevada Power and Sierra Pacific Power Company determined that there are large amounts of untapped conservation potential in their residential, commercial and industrial classes that could be achieved, at a cost less than more traditional resource options. The benefits of this "least-cost" planning process to the utilities have already in part been realized. Moody's recently raised the bond rating of Nevada Power Company two full steps, from Baa1 to A2. In their list of reasons for the increased rating, Moody's mentions the Company's resource plan.

Conclusion

Resource planning is the most critical decision which utility managers face. The results of demand and supply option decisions which the utility makes today set the pattern for rates for years to come. Thus, it is essential to insure that utility management engages in a review process that is likely to result in the selection of future resource options which are in the best interest of ratepayers and shareholders alike. As utilities redefine their role as one of providing customers with energy services, the mandate of providing electricity to customers at the lowest possible cost, will be more readily obtained.[21]

As discussed earlier, many jurisdictions have already begun to make this important transition. None to date, however, have developed a formalized process that insures integrated least-cost resource acquisition.

Nevada's resource planning process, we believe, establishes a model for an integrated system that results in not just better planning but a synegistic effect which will result in refocusing utility direction from the traditional role of a marketer of electricity to a provider of least cost energy services.

We hope that through careful implementation and review, Nevada's resource planning process, as embodied in the statute and regulations discussed above, will achieve the goals and objectives of regulatory Commissions throughout the country; that is to ensure adequate electric service at the least possible cost.

Footnotes

1. Soft Energy Paths, Amory Lovins, Ballinger Publishing Co., Cambridge, Mass. 1977.

2. "Electric Markets in the 1990's: Feast or Famine?", Roger F. Naill and Roger W. Sant, Public Utilities Fortnightly, April 26, 1984.

3. "A New Direction for An Electric Utility - A Commissioner's Viewpoint", the Honorable Hamp Baker, Public Utilities Fortnightly, November 22, 1984, pg. 21.

4. "Pacific Northwest Electric Power Planning and Conservation Act", Bonneville Power Administration, U.S. Department of Energy, December 5, 1980.

5. "Northwest Energy News", Northwest Power Planning Council, Volume 3, No. 6. November/December 1984.

6. "Warren-Alquist State Energy Resource Conservation and Development Act, Public Resources Code Section 25000, et seq." California Energy Commission, January 1983.

7. Conversation with David E. Morse, Manager, Systems Office, California Energy Commission, July 13, 1984.

8. Ibid, #5.

9. Personal discussions between the authors and Staff of the California Public Utilities Commission at the November 1984 NARUC Convention, Los Angeles, California.

10. "Order Adopting Rule Amendments", before the Florida Public Service Commission, Docket No. 820337-EGCRA, Order No. 11405, issued 12-13-82.

11. Ibid #10.

12. "State of New York, Energy Law, Chapter 17-A", July 26, 1976.

13. New York Public Service Commission, Order 84-15, May 1984.

14. "Amended Substitute Senate Bill No. 378", State of Ohio, June 1, 1982.

15. 196,491 Wisconsin Statutes and Chapter PSC 111, "Plans and Certificates for Major Electric Facilities", Wisconsin Administrative Code.

16. "Public Utility Regulatory Policy Act", Public Utility Commission of Texas.

17. "Substantive Rules", August 1984 Edition, Public Utility Commission of Texas.

18. Ibid #3.

19. Nevada Revised Statutes, Section 704.741-746; 751; 890.

20. Ibid #19.

21. Ibid #1.

SOLAR ENERGY INDUSTRIES ASSOCIATION Suite 533 1717 Massachusetts Avenue, N.W. Washington, D.C. 20036 (202) 483-6225

July 17, 1985

Representative Don Fuqua
Chairman
House Science and Technology Committee
Washington, DC 20515

Dear Representative Fuqua:

The following are answers to the questions posed in your May 13, 1985 letter to me as a result of the Subcommittee on Energy Development and Applications hearings held on March 5, 1985.

Sales of the solar heating and cooling industry were approximately $700 million in 1984 with the remaining $300 million in sales attributable to the photovoltaics and solar thermal power industries. Over 200 U.S. companies manufacture solar equipment and over 6000 companies distribute, install and service solar equipment. I have enclosed the newly published "Statistical Analysis of the Solar Energy Industry" for your review. Federal support for R&D through the solar buildings program frankly can go on indefinately. The Solar Energy Industries Association believes that if federal energy policy translates into research for the conventional energy industries that research for the solar industries be continued as well. Activities which need to be emphasized in the solar buildings program include transferring results of research from our national laboratories through a more institutionalized approach to the private sector, support for solar cooling research, integration of energy conservation-passive solar-active solar in buildings, and technical assistance in production and materials to lower costs for manufacturing.

Elimination of FY 1986 funding of the International Solar Energy Program proposed by the U. S. Department of energy is both short-sighted and ill-advised. The program has developed materials very useful in international marketing, supported industry participation in international trade shows, and helps the private sector in obtaining guidance and information not obtainable through other means. The program should be funded at the $1.5 million level annually. At a time when our international competitors are highly subsidizing their solar industries so they can compete internationally, it would be foolish for the United States to relinquish our lead which has seriously eroded in the last few years.

The Solar Energy Industries Association has been strongly solicited by the U.S. Department of Energy program managers to develop a multi-year plan. In the solar buildings program, in particular, industry representatives has been invited to participate in an open and well-planned program to solicit our views. Unfortunately, since the departure of Secretary of Energy Donald Hodel, the industry has not had the access or received requests for input at the policy level of the U.S. Department of energy which is essential for developing a multi-year plan.

The greatest problems with the proposed levels of funding and allocation of activities in the FY'86 Solar Thermal Budget involve support for the solar thermal power program (high temperature solar thermal power for industrial process heat and electric power generation) and the monies for utility/industry projects in the photovoltaics program. The Solar Thermal Power Division of SEIA strongly recommended a funding level of $39 million to continue efforts essential for pushing solar dishes, troughs and other focus technologies past the demonstration phase into the marketplace. Moves to cut the program to $26 million will seriously hurt this goal unless the Committee takes corrective action. In addition, over $9 million from the DOE photovoltaics program will be unused this year which was intended for a 50/50 industry/utility cost-shared project. The Solar Energy Industries Association requested that these monies be reallocated for use in utility/industry projects where the industry would pick up 70% and the U.S. Department of Energy would account for the remaining 30%, the risk amount. In both cases, the solar industry needs stronger support from the Secretary of Energy and the key Congessional Committees to make these programs operate more effectively in support of the solar industry.

I hope this letter responds to your four questions forthrightly. Please feel free to have your staff contact me if you need further information or elaboration. Thank you for your support and interest in solar energy.

Sincerely,

Scott Sklar
Director of Government Relations

SS/vj

SEIA®

STATISTICAL ANALYSIS OF THE SOLAR ENERGY INDUSTRY

Prepared for

SOLAR ENERGY INDUSTRIES ASSOCIATION

by

Jeffry J. Erickson
Research Analyst

STATISTICAL ANALYSIS OF THE SOLAR ENERGY INDUSTRY

INTRODUCTION

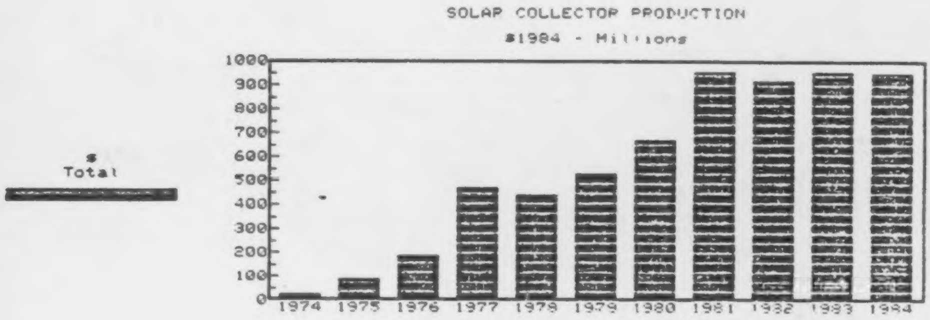
This report was prepared to provide a statistical summary of the solar energy industry. The Solar Energy Industries Association undertook this project to provide essential statistics for analyzing the size and structure of the industry and to document the impact of the solar energy industry on local, state, and regional economies.

SEIA contracted Market Dynamics, Inc. to perform a survey of the industry to obtain data on production, sales, marketing costs, taxes, and employment. Jeff Erickson, of SEIA, prepared the report using the survey results and information from the Department of Energy and a variety of other sources.

The statistical database available for examining the solar energy industry has been quite sparce and scattered, with the exception of statistics gathered by the Energy Information Administration. Several data points are not tracked on a regular basis which limits the ability to analyze developments within the industry. This report attempts to gather the most important statistics available. Where numbers have not been developed in existing sources extrapolations were made from reliable statistics to generate approximations. Where appropriate, any assumptions made have been listed.

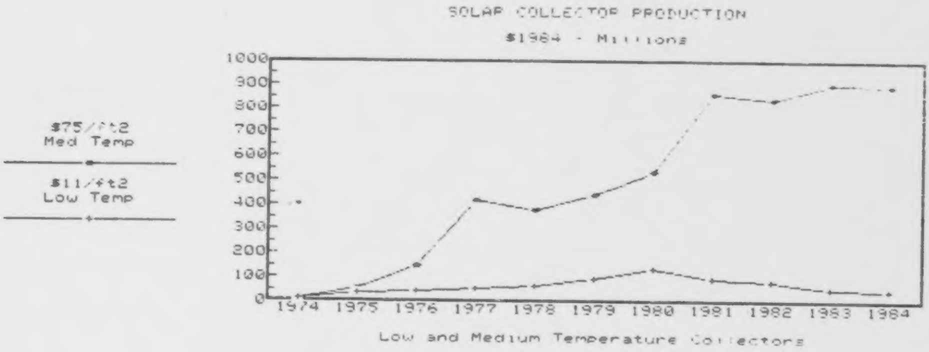
TOTAL PRODUCTION

This section provides a general overview of the size and shape of the solar heating and cooling industry in the United States. The following graph indicates that the industry experienced a steady growth from 1974 through 1981 at which time total sales leveled off. The corresponding table follows the next graph.



PRODUCTION BY TYPE

Most of the drop in total sales can be attributed to the decline in low temperature collector sales, but medium temperature sales leveled off at the same time. Low temperature collectors are generally used for heating swimming pools, while medium temperature collectors are used for domestic hot water, space heating, and space cooling. Some attribute the decline in low temperature collector sales to a saturation of the market. The following graph indicates the changing market for low and medium temperature collectors.



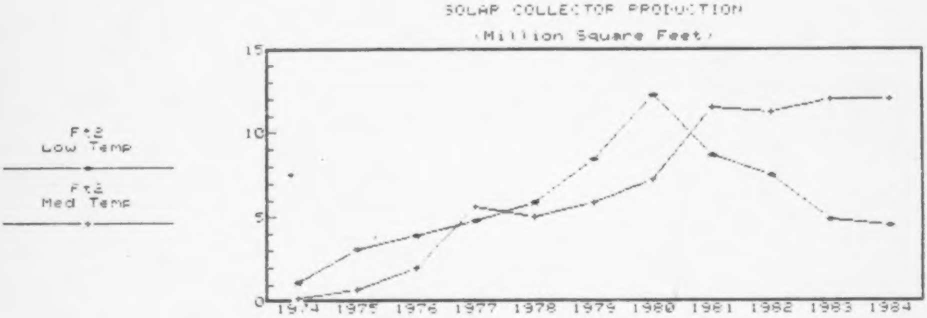
SOLAR COLLECTOR MANUFACTURING
($1984 in Thousands)

	Low Temperature	Medium Temperature	Total
1974	12,507	10,275	22,782
1975	33,286	53,775	87,061
1976	42,636	144,375	187,011
1977	52,173	417,675	469,848
1978	64,592	374,100	438,692
1979	92,345	439,275	531,620
1980	134,563	537,375	671,938
1981	95,447	859,200	954,647
1982	82,236	835,875	918,111
1983	53,383	898,125	951,508
1984	49,269	895,425	944,694

SOURCE: SEIA estimates based on Energy Information Administration, Solar Collector Manufacturing Activity. Assumptions: Average size and cost to the final consumer: Low temperature $3400-3500 for eight 40 square foot panels (320ft^2) = $11/ft^2; Medium temperature $4500 for two panels covering 60ft^2 = $75/ft^2. See Note 1.

PRODUCTION IN SQUARE FEET

Most pool heaters are large, plastic, low temperature solar collectors, while most water and space heaters use variations of medium temperature flat plate collectors -- usually made of aluminum and/or copper, glass, insulation, and sometimes plastic. The average pool heater is made of eight 40 square foot panels. The average domestic hot water system uses two panels covering 60 square feet. Production in square feet gives another indication of the development of the industry.



SOLAR COLLECTOR MANUFACTURING
(THOUSAND SQUARE FEET)

	Low Temperature	Medium Temperature	Total
1974	1,137	137	1,274
1975	3,026	717	3,743
1976	3,876	1,925	5,801
1977	4,743	5,569	10,312
1978	5,872	4,988	10,860
1979	8,395	5,857	14,251
1980	12,233	7,165	19,398
1981	8,677	11,456	20,133
1982	7,476	11,145	18,621
1983	4,853	11,975	16,828
1984	4,479	11,939	16,419

SOURCE: Energy Information Administration, Solar Collector Manufacturing Activity. See Note 1.

ANTICIPATED INDUSTRY GROWTH

In SEIA's survey solar collector manufacturers were asked to describe their expected performance in their coming fiscal year -- the 1984-85 fiscal year. All manufacturing areas expected to increase their sales. Thermosiphon and integral collector storage (ICS) companies expected to increase sales the most, reflecting a trend in the market toward passive solar collectors. Rapidly increasing air collector sales have produced optimism in the active space heating sector of the industry. tive water heating companies predicted the least growth but till expect to increase sales 6.52 percent over their previous fiscal year.

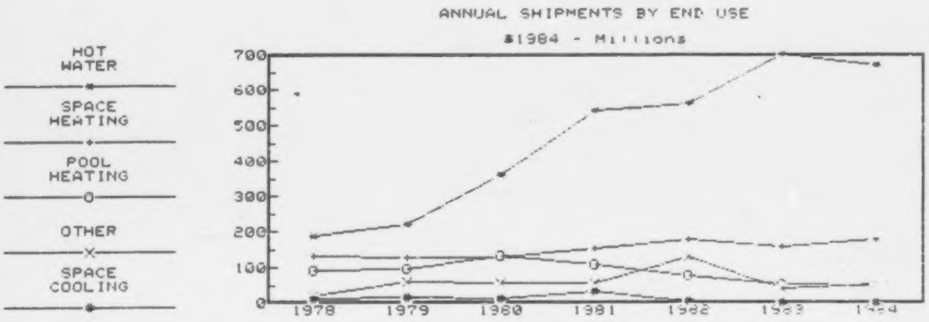
ANTICIPATED GROWTH IN INCOME
1983-1984 to 1984-1985

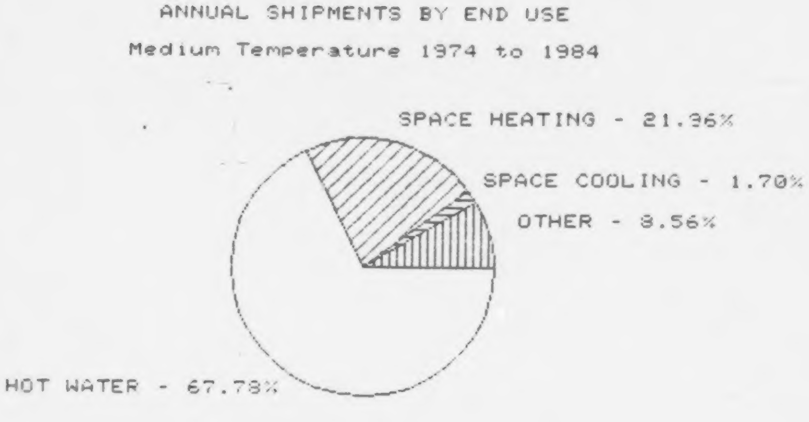
Category	
Active Space Heating	17.82%
Active Hot Water	6.52%
Thermosiphon	97.41%
Integral Collector Storage	71.33%
Pool heating	28.97%
Other	48.32%
Non Collector Solar Sales	14.86%
TOTAL	29.09%

SOURCE: SEIA survey of the industry.

SALES OF COLLECTORS BY END USE

Solar collectors are used in four primary settings: pool heating -- primarily using low temperature collectors, and domestic hot water (DHW), space heating, and space cooling -- using medium temperature collectors. Pool heaters outsold medium temperature systems for several years in terms of square feet sold, but medium temperature uses have dominated the market in terms of dollars, as the previous graphs indicated. Within the medium temperature market, DHW uses predominate. The following line graph illustrates the relative sizes of the various sectors of the industry. The following pie chart indicates the relative size of the various components of the medium temperature solar collector market. The corresponding tables can be found on the following page.





TOTAL RETAIL SALES BY END USE
(Thousands of 1984 Dollars)

	POOL HEATING	HOT WATER	SPACE HEATING	SPACE COOLING	OTHER*	TOTAL REPORTED DISTRIBUTION
1978	90,761	188,475	130,200	13,425	20,100	442,961
1979	94,061	221,850	129,150	17,400	59,175	521,636
1980	132,319	359,250	126,600	11,700	54,975	684,844
1981	107,591	540,300	151,275	30,600	54,225	883,991
1982	77,385	558,300	177,525	5,475	127,725	946,410
1983	53,229	699,225	156,150	1,875	41,925	952,404
1984	48,697	669,750	177,750	900	51,000	948,097
Total	604,043	3,237,150	1,048,650	81,375	409,125	5,380,343

* Total of Industrial Processing, Agricultural Processing, and Other.

SOURCE: Derived from Energy Information Administration, Solar Collector Manufacturing Activity.

ANNUAL SHIPMENTS BY END USE
(Thousand Square Feet)

	POOL HEATING	HOT WATER	SPACE HEATING	SPACE COOLING	OTHER*	TOTAL REPORTED DISTRIBUTION
1978	8,251	2,513	1,736	179	268	10,635
1979	8,551	2,958	1,722	232	789	14,251
1980	12,029	4,790	1,688	156	733	19,398
1981	9,781	7,204	2,017	408	723	20,133
1982	7,035	7,444	2,367	73	1,703	18,621
1983	4,839	9,323	2,082	25	559	16,828
1984	4,427	8,930	2,370	12	680	16,419

* Total of Industrial Processing, Agricultural Processing, and Other.

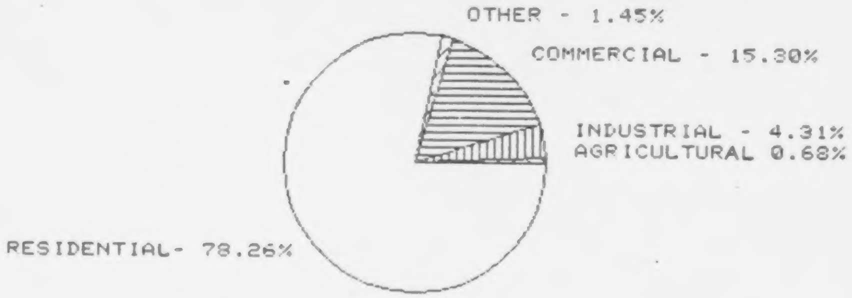
SOURCE: Energy Information Administration, Solar Collector Manufacturing Activity

ANNUAL SHIPMENT BY MARKET SECTOR

Solar collectors are used in a variety of settings, from industrial process heat to pool heating to domestic hot water. The predominant market, however, is in the residential sector. Since 1978 the residential sector has used 78 percent of all square feet of solar collectors sold in the U.S. In 1984 it accounted for 85 percent. Commercial uses have accounted for 15 percent while all other uses combined only account for 6 1/2 percent. The following pie chart illustrates the total distribution for 1978 through 1984. The corresponding table follows the chart.

ANNUAL SHIPMENTS BY MARKET SECTOR

1978 TO 1984



ANNUAL SHIPMENTS BY MARKET SECTOR
(Thousand Square Feet)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	AGRICULTURAL	OTHER	TOTAL*
1978	8,095	1,848	163	140	145	10,492
1979	11,387	2,015	314	120	427	14,251
1980	16,077	2,417	488	94	321	19,398
1981	15,773	2,561	1,518	122	160	20,133
1982	13,729	3,789	560	161	381	18,621
1983	11,780	3,039	1,665	97	247	16,828
1984	13,980	2,091	289	53	6	16,419
1978-84	90,821	17,760	4,997	787	1,687	116,142

* Totals may not equal sum of parts due to independent rounding.

SOURCE: Energy Information Administration, *Solar Collector Manufacturing Activity*

SOLAR ENERGY INSTALLATIONS

Reliable, consistent statistics on solar energy installations covering more than a year or two do not exist. In order to get a rough approximation, an extrapolation from existing data was undertaken. The following figures should not be considered definitive but they will give an indication of the size of the market and the trends in installations. Notes on the assumptions made in producing these numbers can be found in Note 3 at the end of this document.

ACTIVE SOLAR INSTALLATIONS

POOL HEATING

	Single Family	Multi-Family	Commercial	Total
1978	20,905	483	68	21,457
1979	21,666	501	71	22,237
1980	30,478	704	99	31,281
1981	24,782	573	81	25,436
1982	17,825	412	58	18,295
1983	12,261	283	40	12,584
1984	11,217	259	37	11,513

HOT WATER

	Single Family	Multi-Family	Commercial	Total
1978	39,789	468	50	40,307
1979	46,835	550	59	47,444
1980	75,842	891	95	76,828
1981	114,063	1,340	144	115,547
1982	117,863	1,385	148	119,397
1983	147,614	1,735	186	149,534
1984	141,392	1,661	178	143,231

SPACE HEATING

	Single Family	Multi-Family	Commercial	Total
1978	6,527	170	62	6,759
1979	6,475	168	61	6,704
1980	6,347	165	60	6,572
1981	7,584	197	72	7,853
1982	8,900	231	84	9,215
1983	7,828	203	74	8,106
1984	8,911	232	84	9,227

SPACE COOLING

	Single Family	Multi-Family	Commercial	Total
1978	734	1	3	738
1979	951	2	4	957
1980	639	1	3	643
1981	1,672	3	7	1,683
1982	299	1	1	301
1983	102	0	0	103
1984	49	0	0	49

SOURCE: SEIA's estimates, derived from Energy Information Administration, Solar Collector Manufacturing Activity.

ANNUAL SHIPMENTS BY LOCATION AND COMPANY HEADQUARTERS

Most states have solar collector manufacturers. Several states are particularly noted for being in the forefront of the solar industry. Florida has a long history in solar, as does California. In 1984 the top seven states were California, Florida, New York, Colorado, Arizona, Ohio and New Jersey. California accounted for 35 percent of the market, Florida 19 percent and New York nine percent. The following table lists production by state for the last four years.

ANNUAL SHIPMENTS BY LOCATION OF COMPANY HEADQUARTERS[a]

(Thousand Square Feet)

Location[b]	1984	1983	1982	1981
Alabama	183	130	223	126
Arizona	767	890	858	730
California	5,725	6,579	6,076	10,544
Colorado	818	718	1,019	487
Connecticut	200	W	35	93
Florida	3,093	2,886	3,876	1,652
Georgia	W	25	27	72
Hawaii	104	19	26	W
Illinois	17	82	32	142
Indiana	39	W	W	W
Iowa	208	93	57	26
Kansas	0	W	W	14
Maine	45	W	W	W
Maryland	0	W	W	W
Massachusetts	49	W	163	141
Michigan	480	W	65	28
Minnesota	35	W	302	111
New Hampshire	38	W	27	W
New Jersey	640	691	1,139	1,902
New Mexico	340	W	583	W
New York	1,454	1,968	1,670	2,036
North Carolina	50	W	250	12
Ohio	680	252	104	251
Oregon	92	65	83	W
Pennsylvania	94	W	174	271
South Carolina	W	W	20	15
Tennessee	W	155	365	167
Texas	476	W	421	535
Virginia	368	W	383	309
Wisconsin	9	W	28	38
Other[c]	415	2,276	616	431
U.S. Total[d]	16,419	16,828	18,621	20,133

[a] Includes adjusted data for nonrespondents.

[b] Location refers to the address of company headquarters which is not necessarily the location of the manufacturing installation.

[c] Total for States having less than three respondents.

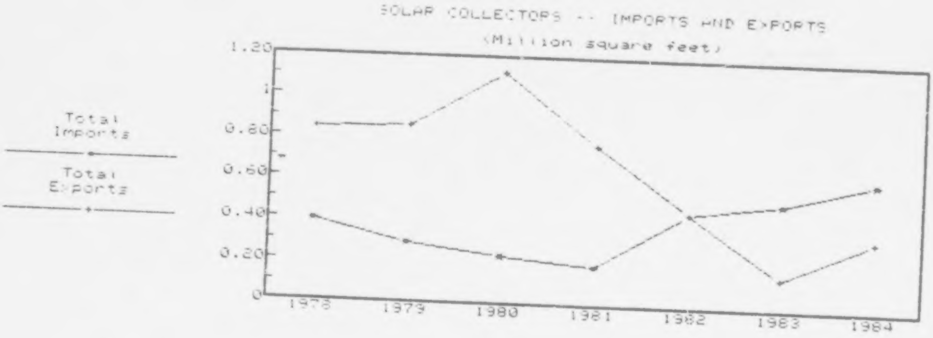
[d] Sum of components may not equal total due to independent rounding.

W = Value withheld to avoid disclosure of company data.

SOURCE: Energy Information Administration, Solar Collector Manufacturing Activity.

IMPORTS AND EXPORTS

After rising between 1978 and 1980, solar collector exports declined for three years until they experienced a modest increase in 1984. Solar collector imports exhibited the opposite trend and surpassed exports in 1981, as the graph below illustrates. Until 1982, low temperature exports were significantly higher than medium temperature exports (data not available after 1982). In 1982 low temperature exports accounted for 70 percent of all solar collector exports. Similarly, medium temperature imports were higher than low temperature imports. Medium temperature imports accounted for 84 percent of imports in 1981, the last year itemized import data were available.



SOLAR COLLECTORS
IMPORTS AND EXPORTS
(Square Feet)

	Total Imports	Total Exports
1978	395,594	839,879
1979	290,405	854,890
1980	235,019	1,115,058
1981	196,000	771,000
1982	455,000	455,000
1983	511,000	159,000
1984	621,000	348,000

SOURCE: Energy Information Administration, Solar Collector Manufacturing Activity

See Note 2.

CORPORATE PERFORMANCE INDICATORS

According to SEIA's survey, 54% of the companies reported increased profits in their last fiscal year, 38% reported decreased profits, and 8% reported no change. Decreased profits, while fewer in number, were large, yielding a negative profit rate overall, as seen in the following table.

CORPORATE PERFORMANCE INDICATORS

Profit (as % of sales)	- 4.40%
Return on equity	40.72%
Net income (as % of sales)	4.07%
Long Term Debt to Equity	55.20%

SOURCE: SEIA survey of the industry.

EMPLOYMENT

At peak production, solar energy collector manufacturers employed 3,485 full time and 2,175 part time men and women in 1984. At their lowest production levels since 1982 they employed 2390 full time and 170 part time men and women.* Women and minorities form a significant portion of the solar work force as the following figures show.

According to the Solar Energy Industries Association, there are approximately 6,000 retail distribution businesses conservatively employing at least 30,000 people in administrative, sales, installation, and service positions.

* Derived from SEIA survey and EIA statistics.

MINORITY AND WOMEN EMPLOYMENT PERCENT OF WORKFORCE

Female	17.38%
Minority**	22.60%

** American Indian, Asian, Black, Hispanic, and Mexican American.

DISTRIBUTION

The distribution and retail sale of solar energy equipment involves a very large number of companies. Few statistics exist to give an indication to the true size of this aspect of the industry, however, SEIA's survey did provide some information on distribution and retailing. Some solar collector manufacturers act only as manufacturers and leave retail sales to independent dealers and distributors, while other companies not only manufacture collectors but also sell and install them. The following table indicates the percent of companies using independent distributers and dealers, and engaging in direct retail sales.

DISTRIBUTION

	Percent of Companies Using*	Percent of Sales
Independent Distributors	65.52	39.70
Company Dealers	13.79	8.70
Independent Dealers	82.76	35.30
Direct Mfg. Retail Sales	NA	9.30
Other	17.24	7.00
		100.00

* Total sums to greater than 100 percent since some companies use more than one method.

SOURCE: SEIA survey of the industry.

NOTES ON STATISTICS AND GRAPHS

NOTE 1: Three factors should be taken into consideration in interpreting this table. The Energy Information Administration reports on the activities of only those companies which maufacture in the United States. As a result, this table does not accurately indicate the size of the domestic market since the totals do not include imports by companies which do not manufacture in the US, this is particularly relevant for the low temperature market. Also, the number of manufacturers included in the survey is not necessarily a complete set since it is unlikely that many of the small, independent entrepreneurs producing a small number of collectors are included. This may represent a fairly sizeable quantity. Finally, over the course of this publication's life, complaints have arisen from various sectors about its accuracy. Some believe that it consistently understates the true totals; others believe that it overstates them. While the totals may not indicate the true size of the industry, the numbers should give a good general picture of the manufacturing trends.

NOTE 2: The Energy Information Administration surveys only companies which manufacture collectors in the US, they do not survey companies which import but do not manufacture. As a result the figures provided understate imports. Some claim that the real figures are significantly higher, particularly for the low temperature (mostly pool heating) sector.

NOTE 3: These figures were derived in the following manner: The square footage manufactured for each sector (taken from Energy Information Administration numbers) was divided by the average square feet for a typical installation. Averages were derived from the EIA's Solar Collector Installer's Survey and the author's estimates. The average installation sizes used in square feet were:

- Pool Heating
  - Family -- 371
  - Multifamily -- 854
  - Commercial -- 1210
- Hot Water
  - Family -- 60
  - Multifamily -- 215
  - Commercial -- 502
- Space Heating
  - Family -- 250
  - Multifamily -- 307
  - Commercial -- 845
- Space Cooling
  - Family -- 222
  - Multifamily -- 2641
  - Commercial -- 3851

[Additional statements for the record follow:]

Testimony for the Record
Subcommittee on Energy Development and Applications
Committee on Science Technology
U. S. House of Representatives

Photovoltaic Solar Cell Research and Development
at the
Department of Energy

by

Allen M. Barnett, Professor
Electrical Engineering Department
University of Delaware

My thoughts and suggestions on the photovoltaic solar cell program are based on my experience in product development including the management of an electronic component development company and at the General Electric Company.

I am the General Chairman of the 18th Institute of Electrical and Electronics Engineers Photovoltaic Specialists Conference, the largest photovoltaic professional conference in the world.

I am concerned that the excitement with the technology and the business opportunities which is enjoyed by the professionals in the field is not realized in Washington. In contrast, the view from the Government appears to be one of discouragement.

The drastic decline and current austerity of the photovoltaic budget has led to substantial decreases in:

a) Innovation
b) Small business participation
c) University participation
d) Technology transfer

It is only natural that the good program managers at the Department of Energy protect their best big programs (which are also shrinking). There have been continually reduced opportunities for innovative new programs.

The United States Photovoltaic Program has been the world leader in the development of innovative new ideas for this market which is rapidly growing from several hundred million dollars to $1 billion by the end of this decade and $10 billion by the year 2000. As the U. S. research program is reduced in size and effectiveness, the market share is being lost by U. S. companies.

U. S. developed technology is fueling the growth of international companies. These international companies are now leading in specific technology areas. Clearly, the problems of off-shore competition in the U. S. semiconductor industry are now being experienced by our photovoltaic companies who are not yet well enough established in the market to fight this competition without Government assistance.

Following are some suggestions:

1) Add a semiconductor device, design, and development component to the current materials research program.

A semiconductor device approach is based on new designs which lead to improved solar cell performance without requiring perfect materials. It is device design and innovation which fueled the semiconductor electronics industry, including Intel, Texas Instruments and countless successful innovative small companies. This high technology industry growth was fueled by strong support of academic research.

An example of the type of innovative device design opportunity which does not fit in the current program is thin-film crystalline silicon. The opportunity comes from new device designs which do not require perfect silicon sheet materials. The current materials research program does not include crystalline silicon. The advanced silicon sheet is focussed on wafer quality materials and also excludes device design based on less than perfect new materials.

The thin-film silicon problem will require some innovative new approaches, most likely in the device design area. The solution of this problem and many other similar high risk, high payoff approaches can lead to a true breakthrough in the cost/performance standard.

Adding device design to the current program can lead to substantial new opportunities.

2. Consider adding photovoltaic water pump systems to the list of preferred exports for agricultural assistance to less developed nations.

It is clear that photovoltaic water pumps can have long term beneficial impact. These benefits can be realized by allocating a small fraction of the funding currently reserved for food exports and other agricultural assistance.

3. Aggresively review the Government Agency plans to purchase stand-alone electricity systems, i.e., diesels.

For example, the Voice of America is planning to purchase 1.5 billion watts of new diesel generators. Doesn't life cycle costing favor photovoltaics for many of these applications?

4. Across the board raids on the current photovoltaic research budget must be avoided.

   If new projects are to be funded, separate funds must be allocated. There is no more room for further decreases in the research budget.

The creative energies of U. S. technology can lead to technological and market dominance of this new high technology, rapidly growing industry. Limited encouragement and assistance by the Government can be a very effective catalyst.

Allen M. Barnett
February 27, 1985

February 27, 1985

BIOFUEL ENERGY SYSTEMS

Statement by Professor David Pimentel
College of Agriculture and Life Sciences
Cornell University

Biomass can make an important contribution by supplying up to 11% gross of the nation's energy needs by the year 2000. But this will not happen unless a major research effort is made.

At present in the United States, the fuel supplied by biomass is about 2 Q, or nearly 3% of the total U.S. energy consumption of 71 Q (gross). By year 2000, with appropriate research and development, biomass has the potential of supplying the nation with about 11 Q or about 11% of projected U.S. energy consumption (100 Q).

Biomass resources have the distinct advantages of being a renewable energy source and, in some areas, being a locally abundant resource (e.g., fuelwood).

Biomass energy potential is primarily constrained by limits on agricultural and forest production and therefore priority in research should be given to biomass production instead of biomass conversion technologies.

Because of serious soil erosion and water runoff problems associated with current agricultural and forest production practices, high priority should be given to research on biomass production systems that protect the environment.

Remarks by

Glenn H. Lovin, President
International Cogeneration Society

I would like to express my appreciation for the opportunity to appear before the Subcommittee on Energy Development and Applications and give my industry's view of the Fiscal Year 1986 Authorization for the Department of Energy's Renewable Energy Programs.

The International Cogeneration Society was chartered in 1978. Its membership is diverse. It includes resource companies, the energy intensive industries, utility companies, equipment manufacturers, investment banking firms, law firms, accounting firms, insurance companies and individuals from all ranks of the business community. Its focus, however, is not as diverse. We concentrate on cogeneration, defined as a system that produces electricity and thermal/mechanical shaft power from the same primary energy source. I will not give a more detailed description of cogeneration or its applications at this time. That would be presumptuous since it was the U. S. Congress that passed the Public Utility Regulatory Policies Act (PURPA) in 1978.

Cogeneration, as you know, is an old and proven technology. Between the late 1880's and early 1900's, oil-and gas-fired cogeneration was used throughout Europe and the United States. In 1900, over 59% of total U.S. electric generation capacity was located at industrial sites. With the advent of large central station power plants and utility networks, industrial power plants declined to approximately 3% of electric capacity in the U.S. by 1979. After the passage of PURPA and the formation of the International Cogeneration Society, we issued a report indicating some 9,000 to 13,000 MW of cogeneration capacity in the industrial sector at the end of 1979. The Federal Energy Regulatory Commission (FERC), certified 440 MW of new capacity in 1980, 880 MW in 1981, 3,846 MW in 1982, 2,744 in 1983; in 1984 FERC certified 5,138 megawatts.

COGENERATION POTENTIAL

There has been a resurgence of interest in cogeneration as demonstrated by the certifications for new plants. While electricity production has declined at the industrial plant site, since the 1940's, thermal load suitable for cogeneration has increased stadily since World War II. The potential for cogeneration in industry has been the subject of many efforts. The most recent is the Department of Energy's study, Industrial Cogeneration Potential, 1980-2000, Targeting of Opportunities at the Plant Site (TOPS) and the TOPS update in 1984. They indicate a potential of some 47,000 megawatts cogeneration capacity in the industrial sector by the year 2000. The potential for cogeneration development in the commercial, institutional and agricultural sectors is not yet fully documented. It appears that with the development of modular or "packaged sized" cogeneration systems, this market will develop rapidly over the next few years.

RESEARCH: THE FEDERAL GOVERNMENT'S ROLE

There may be some concern before this Subcommittee today whether or not cogeneration will play a significant role in the future. Will cogeneration will achieve the projected 47,000 MW by the year 2000. Existing and certified capacity equals some 24,000 MW at the end of 1984. We need only 2,000 MW in each of remaining years to go over 50,000 MW by the year 2000. This does not include capacity for hospitals, universities and commercial structures or municipal waste-to-energy projects.

Why should the Federal Government, through the Department of Energy, sponsor research to enhance the cogeneration industry? The answer is quite clear: It is in the national interest and industry will not do it alone. Many think of large industries with billions of dollars and large research staffs and do not immediately understand why there should be any Federal funding of research for saving energy and improving energy efficiency in industry. Many conclude that industry will do the necessary research on its own and the Federal monies can be more effectively distributed elsewhere.

Industry will, of course, achieve significant energy savings on its own. That has been demonstrated this last year with the certification of 5,000 MW of cogeneration capacity. It is important, however, to examine more closely the industrial capital and research investment decision process to see what industry will not do without Federal stimulus.

Capital investment decisions, in major industries, such as steel, pulp and paper, food processing and petroleum refining are influenced by factors beyond those of simple profit maximization, although rate of return ROI is probably the most important element in capital investments.

The majority of research in the energy-intensive industries is undertaken by the chemical industry and the least is by the textile industries. Two steel companies account for nearly 70 percent of the total research expenditures to improve energy efficiency in the steel industry. Three companies conduct 43 percent of the research for the widely fragmented textile industry.

It would appear, therefore, that the results of industrial energy efficiency by industry on its own would likely be held proprietary by a few dominant companies, whereas the Federally cost-shared research would be available to all industries. DOE supported research enables equitable dissemination of new energy efficient technologies.

There is an important role for the Federal Government in providing the support necessary to help industry develop the more promising cogeneration technologies that can use fuels other than oil and that can produce significant amounts of electricity. Research should be directed at advanced combustion systems such as fluidized beds that can burn solid fuels cleanly and coal mixtures that can increase the use of coal without impacting the environment. Cogeneration is already saving millions of dollars for some industries. Given access to technologies for using coal, cogeneration could be used to off-set the need for new central station utility plants in several parts of the country. It could save consumers millions of dollars and create new jobs in every sector. Federal Government support is essential if we achieve some of these goals.

TESTIMONY SUBMITTED TO
HOUSE SCIENCE & TECHNOLOGY COMMITTEE
U.S. CONGRESS

MARCH 5, 1985

By

BYRON WASHOM

REPRESENTING
SOLAR THERMAL POWER DIVISION
SOLAR ENERGY INDUSTRIES ASSOCIATION

Mr. Chairman and members of the House Science & Technology Committee, the Solar Thermal Power Division of the Solar Energy Industries Association appreciates this opportunity to share our views on the FY 86 DOE Authorization Request. Annually we have presented to this committee the technical dividends of the continued support that HS&T has provided this technology. The past twelve months have been our most technically prosperous, but the softening oil prices and potential expiration of the Federal Energy Tax Credits have had a palling effect upon our industry. If this environment continues beyond 1985, our industry will require DOE cost sharing support for the development of the next generation equipment for the one solar technology that can deliver thermal, mechanical, electrical or chemical energy from systems from 25 kW to 400 megawatts in size. The balance of this testimony 1) documents recent technical progress in the field of solar thermal energy, including world record energy conversion efficiencies (over 30%), substantial reduction in the cost of concentrators and collectors, validation of new working fluids and perfection of automated system operations and 2) describes future research needs and major opportunities in materials, storage, controls, process and systems research.

The industry association advocates a budget of $38.5M vs. the Administration's budget of $28.4M in FY 86. The difference between the two budgets relate to three primary areas. First, significant funding for system level design and analysis of central receiver systems has been requested by Congress, but this funding is not included in the Administration's request. Such a "centerpiece" analysis will directly determine the future use of Solar I and the future receiver type and working medium of large commercial scale systems. Second, the distributed receiver program needs to embark on the next generation of collectors, heat engines and receivers and the $8.4M DOE proposed budget should realistically be $13M. Finally, the research program, the technical underpinning of the industry's future, needs to be $11M, including the SERI and university programs.

These industry recommended amounts are comparable to FY 85 expenditures. The technical progress last year clearly justifies past, present and future support for this technology at the level we have recommended. The difference between the Administration's budget and the industry's is one of timing rather than direction. I believe this committee has a sense of the critical need for this technology and appreciates the significance of the long lead times required to achieve market penetration. The market applicability and technical success of the program are well established; the next step is to design, build and test components, modules and systems that will compete in an unsubsidized energy market of the future.

Our industry association is aware how much energy conservation and alternative energy supply production has contributed to reducing the rate of inflation, foreign import requirements and the price that is paid for those imports. Reducing imports in a time of devastating trade deficits is one of the few areas that the United States economy can expect improvement in times of a strong U.S. dollar. "Home grown" energy will always reign supreme over insecure foreign supplies and we should be willing to pay a premium for diversifying and securing our energy supplies, and solar thermal technology has demonstrated that it is on the right path, be it ever so long, and that the technical, economic and political dividends are unquestionable justifications for federal support.

Central Receiver Technology

Significant Events

Reduced Heliostat Costs

The cost of heliostats has been of concern since the central receiver development program began. Typically, heliostats have been estimated to represent between one-third and one-half of a total cost of the central receiver system. Several generations of heliostats have been designed, built, and tested under Department of Energy funding. Long term cost goals have been established (in 1984 dollars) of $100 per square meter for large production runs. The cost of heliostats for Solar One was in the $500 per square meter range.

One private company, using previously developed technology as a basis and incorporating information from their designs of tracking photovoltaic systems, built and tested several generations of prototype heliostats at company expense. The final prototype (shown in Figure 1 along with other, smaller, versions) has a surface area of 149 square meters, more than three times the area of an individual heliostat at Solar One.

In 1984 that company offered to sell its large heliostats in small quantities at a price near $200 per square meter. Prices in this range have been discussed previously by two different private companies, but were based on much higher production rates. The 1984 sales offer indicates that good progress is being made toward the long term goal.

10 MWe Solar Thermal Central Receiver Pilot Plant Computer Control System

The 10 Megawatt Solar Thermal Central Receiver Pilot Plant near Barstow, California, is a showcase for modern digital control system technology. It is unique in the electric utility industry in that the plant is automatically controlled by a Master Control System consisting of an Operational Control System (OCS) computer that supervises two collector field computers, three distributed process controllers, (to control the plant's main process loops), and five programmable process controllers which provide the plant's logic. The master control system also has four computers which supervise the operation of the plant's 1940 microprocessors.

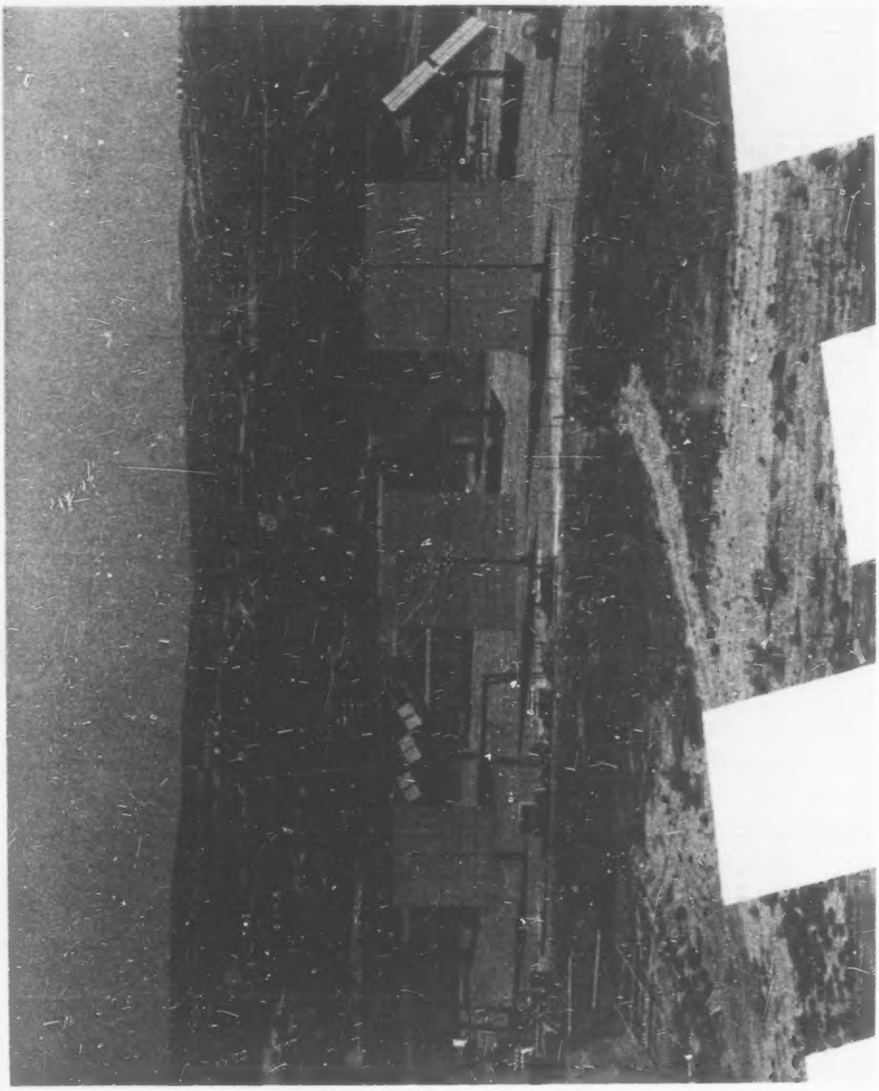


Figure 1 - Prototype Heliostats

The plant operates automatically under the supervision of a single operator (see Figure 2). In the morning the operator, through keyboard commands, positions the heliostats to their standby positions (four tracking points in space near the receiver), initiates water circulation in the receiver and then issues a command to the Operational Control System (OCS) computer to start-up the plant. The OCS computer takes over and automatically directs heliostats to track the receiver, controls receiver flow and puts the various receiver components into operation. When receiver steam conditions are correct, steam is routed to the turbine. The operator then synchronizes the turbine to the electric grid. The plant operates for the rest of the day under the supervisory control of the OCS computer. If conditions change, such as a cloud interrupting the sun's energy, the control system will automatically make adjustments and attempt to keep the plant in the best operating state. If some abnormal event occurs the operator is provided alarm messages that indicate what parameters are out of their normal operating range. The operator can intervene at any time to change any plant operating condition.

Solar One has demonstrated that modern computer control technology can be successfully utilized in the electric utility industry. The operations and maintenance personnel have come from within the utility without any special job descriptions. The control system, coupled with equipment design, has provided a plant power turndown ratio of twenty to one, which is far superior to conventional controls. In addition, the plant has operated during severe cloud transients without evidence of process upsets. In a demonstration, the heliostat images were removed from the receiver for three minutes and then reset on the receiver with a resultant steam outlet temperature excursion of only 15 degrees F.

The Solar One control system allows the operator to devote more of his time to plant operational reliability and efficiency; energy output is increased.

It is anticipatd that in the future the computer will provide even more improvement in operations as the computer control system can be designed to aid the operating and maintenance personnel in diagnosing problems. Accordingly, maintenance information could be combined with the operating information, allowing development of trends and thus helping identify potential failures or causes for efficiency reductions.

The Molten Salt Electric Experiment (MSEE)

The MSEE is a full-system demonstration of an advanced central receiver system using molten salt. The overall goals of the project are to: (1) verify the capability, flexibility and simplicity of an advanced central receiver concept; (2) provide performance information and operating experience on molten salt systems and components for utilities, system designers, component suppliers, and financial institutions; and (3) establish a test bed for component development and advanced controls.

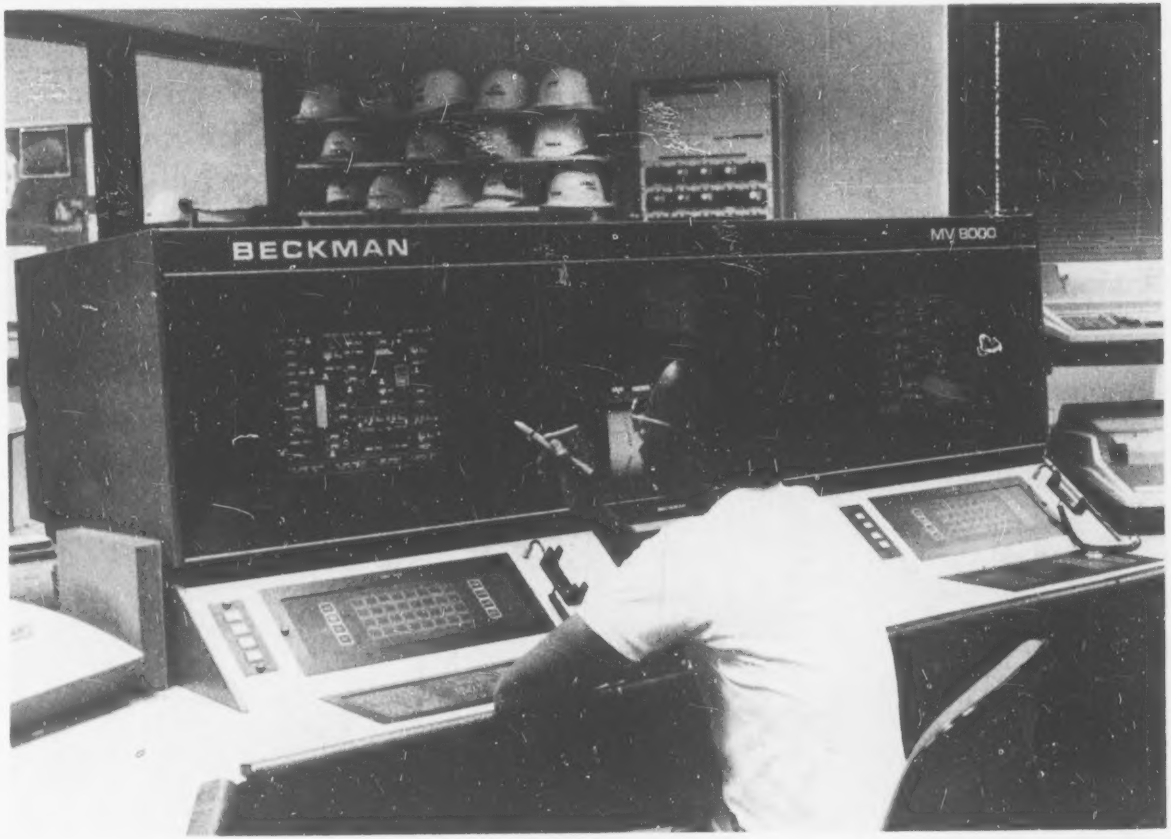


Figure 2 10 Megawatt Solar Thermal Central Receiver Pilot Plant

Computer Control System - Operator Consoles
Operator using a light pen to select a control function

Sandia is technical manager for the $5 million MSEE, which is funded by the U.S. Department of Energy (DOE), a group of utility and industry participants, and the Electric Power Research Institution (EPRI), a research and development arm of the electric power industry. The funds for the project are split roughly 50% from DOE, 25% from industry, and 25% from utility companies. Besides DOE and EPRI, participants include Arizona Public Service Co., the Arizona Solar Energy Commission, Babcock & Wilcox, Black & Veatch Engineers-Architects, Foster Wheeler, Martin Marietta, McDonnell Douglas, Olin Corporation, Pacific Gas & Electric Co., Public Service Co. of New Mexico, and Southern California Edison.

Synchronization of the turbine-generator was accomplished on April 13, 1984 and the full system was operated simultaneously for the first time on May 9.

The status of the MSEE at this time is that the fuel system has been operating for nine months with electrical power from solar energy being fed to the distribution grid; system performance has been monitored and teams of utility operators have received hands-on training; and a third phase - operation of the MSEE as a utility, plus receiver convective loss measurements - is beginning.

Important lessons have been learned from MSEE in three categories: "programmatic" issues, molten salt technology, and central receiver technology. With regard to programmatic issues, MSEE has demonstrated that a central receiver system using molten nitrate salt is technically feasible. The storage system buffers the end use from solar transients, and subsystems and components operate as designed as part of a full system. Digital controls were shown to be viable for both normal operation and emergency shutdown of the system, and the scheme has been favorably received by the utilities. Because MSEE was designed and built to demonstrate a concept rather than to characterize overall system performance of a commercial plant, the parasitic power requirements are disproportionately high. These losses are not representative of losses anticipated for commercial plants.

In the area of molten salt technology, five important issues were revealed. First, the design of thermal conditioning, including trace heaters, wind shielding of valves, and blanket insultation needs special consideration. Second, molten salt pumps also need special design consideration, such as minimizing salt creep into bearings, and controlling temperatures of bearings and seals. Third, proper attention must be given to valves for molten salt flow control. Packing seal designs need to be verified, or more expensive alternatives, such as bellows or freeze-seal valves must be used. Valve seal leak-through must be allowed for in system design. Fourth, no degradation or contamination of the molten salt has been measured; and finally, no corrosion of the containment system materials has been observed during nearly a year of system operation.

The third category of lessons learned from MSEE includes variables relating to all central receiver technology. First, the receiver control system needs rapid feedback of incident flux for transient operation. Second, certain system design simplifications can be incorporated in the future, such as eliminating active control of the cold surge tank. Third, solar flux measurements are required for accurate receiver performance evaluation; in their absence the receiver thermal loss mechanisms are only estimates. Fourth, because the MSEE has been operated as a test facility, integrated start-up times and transient response procedures have not been developed to the degree they would be for a commercial plant. Finally, a water-cooled receiver aperture is not required; the passive aperture design has functioned well at this scale.

The MSEE is an important step in the development of solar central receiver technology. It is also unique in that its management and funding is provided by both the government and the private sector. Valuable lessons have been learned during the construction and checkout phase which will greatly benefit the designers, builders, and operators of future molten salt systems. A test and evaluation program is underway which will determine system performance characteristics, establish a measure of operating flexibility, and allow utility operators the opportunity to gain hands-on experience with the technology and to provide feedback to the designers.

Solar 100

An effort by Southern California Edison and the central receiver industry to achieve a commitment for a 100 MW central receiver facility was suspended in late 1984 due to uncertainty in the financial and regulatory arenas. Unmistakably, the downward spiralling oil prices and the potential expiration of the Energy Tax Credits put a chilling effect on the project's proponents.

Funding Issues for Central Receivers

The Administration's requested FY 86 budget for central receivers is $12.7M, down 17% from the FY 85 budget ($15.3M) and lower than industry's recommendation of $13.5M. What is fundamentally missing from the Administration's budget is the request by Congress in the FY 85 Appropriations Act requiring the development of a centerpiece for the central receiver program. This request by Congress resulted from uncertainty about rival technical and schedule approaches by the utility and manufacturing community; thus, Congress found it necessary for DOE and industry to redefine a critical path to technology development and commercialization. DOE has failed to address the centerpiece issue in the FY 86 request; however, DOE has accurately stated the collector, receiver and systems experiments for this period.

The central receiver oriented utility industry, namely Southern California Edison, Pacific Gas & Electric and Arizona Public Service, have apparently reached an accord of what should be a centerpiece for the central receiver technology. Basically, these three utilities will soon submit to DOE a three volume proposal that will define the critical paths and decision gates for DOE and industry to pursue. Total concensus on the critical path is difficult given the complexity of the technical options and differing system requirements, but agreement on incremental steps to commercialization can be communicated.

When the utilities mentioned submit their three volume proposal to DOE in mid-March, copies will be transmitted to this committee. Funding for the system level analysis and planning by the utility and industrial sector is not provided for in the Administration's FY 86 budget, leaving a possible $6M difference between a fully funded comprehensive research program and a systems analysis program. This is the single largest discrepancy in the industry and DOE budgets.

This utility industry proposal addresses the key issue of retrofitting Solar I with a different and more commercial receiver and working fluid loop, a step they regard as essential to to the future of central receivers. A November 1984 study by Sandia-Livermore discussed the six options that are available for both resolving the Solar I future use issue and the critical commercial receiver design issue. Table ES-1 presents these six options.

In summary, we have witnessed significant technical accomplishments during the past year in central receiver technology and the southwest utility sector has begun the process of formalizing a recommended development path to commercialization. The inability of private industry to finance a 100 MW plant in 1984 was attributed to the failure of the last Congress and the Administration to consider the energy tax credit legislation combined with the effect of softening oil prices on venture capitalists. The DOE budget represents a strong national laboratory research program with component design and testing; however a major programmatic and funding element, central receiver system level planning and analysis, is clearly absent. It was specifically requested in the DOE FY 85 Appropriations Act and the best input for analysis will be forthcoming from the southwest utility industry. The next twelve month effort of this element alone could reach $6M.

TABLE ES-I
DESIGN CHARACTERISTICS OF SOLAR ONE AND SOLAR ONE SYSTEM CONVERSION OPTIONS

DESIGN CHARACTERISTIC	SOLAR ONE	SOLAR ONE CONVERSION OPTION					
		1	2	3	4	5	6
Plant Type	Stand-Alone	Stand-Alone	Stand-Alone	Stand-Alone	Stand-Alone	Stand-Alone	Hybrid
Plant Net Output	10 MWe	10 MWe	10 MWe	10 MWe	10 MWe	10 MWe	10 MWe
Receiver Technology and Output Temperature	Water/Steam Cylindrical 516°C	Salt Flat Plate 574°C	Sodium Flat Plate 574°C	Sodium Flat Plate 593°C	Salt Flat Plate 574°C	Salt Flat Plate 574°C	Salt Flat Plate 574°C
Existing Heliostat Area	71,130 m2	71,130 m2	71,130 m2	71,130 m2	71,130 m2	71,130 m2	71,130 m2
Upgraded or Added Heliostat Area	N.A.	N.A.	N.A.	N.A.	39,000 m2 (Upgraded)	15,000 m2 (Added)	N.A.
Total Heliostat Area	71,130 m2	71,130 m2	71,130 m2	71,130 m2	71,130 m2	86,130 m2	71,130 m2
Field Configuration	Surround	North	North	North	North	North	North
Tower Height	79 m	128 m	128 m	128 m	128 m	128 m	128 m
Storage Technology and Operating Temperature Range	Oil/Rock Thermocline 218-302°C	Salt Two Tank 277-566°C	Sodium Two Tank 277-566°C	Salt Two Tank 277-566°C	Salt Two Tank 277-566°C	Salt Two Tank 277-566°C	Salt Two Tank 277-566°C
Fossil Heater Technology	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	Salt Heater

N.A. – Not Applicable

Distributed Receiver

The Distributed Receiver Program has undergone the most favorable and dramatic change in the last year. The Distributed Receiver Program includes parabolic dishes and parabolic troughs, and both are applicable to converting concentrated sunlight to electric energy by either mechanical, thermal or chemical means. The industry also witnessed two early commercial projects made possible by the energy tax credits. Additionally, one measure of commercial viability is the level of competition, and the past year saw the doubling of companies with major research involvement in the parabolic dish field.

Significant Events

The parabolic dish research program produced module level performances of 31.6% gross (29.4% net) sunlight to electricity conversion efficiency, a world record for all types of solar systems. The Vanguard parabolic dish Stirling module further produced 1200 on-sun and grid-connected hours which significantly improved the understanding of dish systems. The organic Rankine cycle (ORC) system has been in the final stages of development for testing at the Sandia-Albuquerque test facility and this work has included 200 hours of hot bench engine testing and revised automatic control. This same engine has been selectd for a 100 kWe system level experiment at Osage City, Kansas.

Under JPL contract an automatic control system was developed by another contractor for the ORC and worked very well. However, SNLA made the decision to develop a new controller for simplicity. This new system does not contain the data acquisition included in the original system design. Also, an off-the-shelf programmable microprocessor controller was used to alleviate repair problems, via manufacture warranty, and easy reprogramming.

The engine and controls together have been demonstrated in the laboratory environment with success. Power conditioning problems have caused a slight set-back in delivery of the Power Conversion System (PCS) to SNLA's test facility. After March 1985, this will be corrected so that operational testing can begin.

As reported last year before this committee, an industrial team of McDonnell Douglas and United Stirling of Sweden has been formed, under an exclusive cooperative agreement, to privately finance the development of an 11 meter diameter parabolic dish Stirling module. This effort has resulted in a module that was dedicated in December 1984; a 28% net conversion efficiency has since been achieved. The team plans to place three individual modules at selected U.S. utilities, as well as pursue overseas customers.

Three Innovative Concentrator DOE awards have been made which represent a diversity of approaches and sizes from 12 to 15M, with reflective and refractive surfaces. These awards will result in the next generation of concentrators, which are the biggest cost item of the module, even in volume production.

A first innovative concentrator under contract to DOE is the fresnel lens concept that transmits, rather than reflects, sunlight. The genesis of this technology includes a linear trough system to concentrate radiation on photovoltaic cells, and the Dallas/Ft. Worth Airport has the most successful and visible project of this early design. The fresnel point focus device will be 50 feet in diameter, have a 20 year life due to the UV resistance of the durable acrylic plastic lens that will concentrate the sunlight 2000 times.

A second design contract is for a dish 15 meters in diameter; this large size allows dish module output of over 50 kWe, using a Stirling engine power conversion assembly (PCA). Key features of the dish include the isolation of the reflective panel structure from the structure which supports the PCA at the focus, reflective panels which are strucutral elements of the reflective structure, and a lightweight tripod base. Collectively, the dish size and features provide the required low cost, high performance dish. The third award was for a 12M dish consisting of vacuum drawn reflectors using polymer reflective surfaces.

Sandia National Laboratories Distributed Receiver Test Facility

A Distributed Receiver Test Facility has been constructed at Sandia National Laboratories' Solar Thermal Test Facility and is shown as Figure 3. The Distributed Receiver Test Facility will support development and testing of point-focus concentrators, and associated solar-powered heat engines for electrical generation and thermochemical transport systems for thermal applications. The facility also includes line-focus systems, developed under the Modular Industrial Solar Retrofit project, and other line-focus test capabilities. Since the Solar Thermal Test Facility includes the Central Receiver Test Facility, test facilities for all concentrating solar thermal technologies are available at one location.

The test facility will support the test phases of the Small Community Solar Experiments and Innovative Point-Focus concentrator projects as well as ongoing research in line-focus concentrators. Private industry is also planning to utilize the facility for evaluation of privately-funded concentrators. In addition, requests for use of the facility have been received from companies and agencies involved in development of solar power sources for manned space stations.

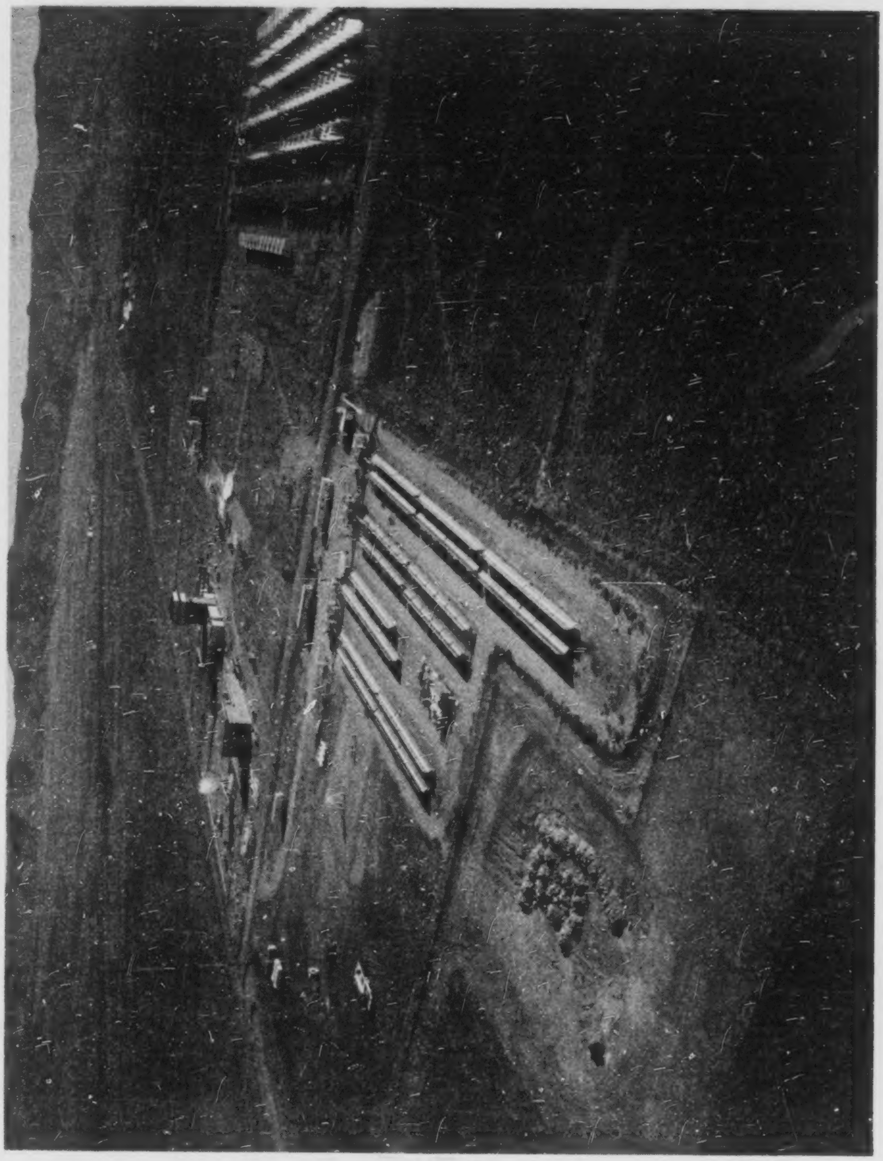


Figure 3 - Distributed Receiver
Test Facility

Last year we bagan to study the value of a central thermal/chemical approach to parabolic dishes, i.e., collecting heat energy at the focal point and transporting it to a central conversion station. The virtues of this approach are two fold. First, the thermal or chemical transfer eliminates the capital and operating cost of having a prime mover at each module's focal point. Second, the lack of demonstrated heat engines due to either exclusive industrial agreements or limited field testing may hold commercialization of this technology hostage in the future. The offsetting factors are the thermal losses and the cost of the thermal piping to the central engine. The technical and programmatic aspects of this approach warrant thorough investigation in parallel with future heat engine development.

The first demonstration of central thermal was the Shenandoah Project, a cooperative effort between the Department of Energy and the Georgia Power Company to design, construct and evaluate an experimental Solar Thermal Total Energy System. The project, which provides process steam and air conditioning as well as electrical power for a Shenandoah, Georgia, knitwear factory, is unique among solar thermal systems in that it utilizes waste heat from the production of electrical power to satisfy other energy requirements. The project was initiated in May 1977. DOE's portion of this activity will conclude with the successful completion of the evaluation phase in March 1985.

A photograph of the Total Energy Project is shown as Figure 4. In the aerial view, the knitwear factory buildings are at the bottom left hand corner of the photograph. Above the factory, on the left side of the water tank are the trailers being used as an office and Visitors Center. The small white building, to the left of the Visitors Center, houses the operations and control equipment, and the area to the left of that contains the high temperature thermal storage tank and other mechanical equipment.

The Solar collectors for the project consist of an array of 114 parabolic dishes, each 23 feet in diameter. At the focal point of each dish is a cavity type receiver capable of transforming the concentrated solar flux (235 suns) into thermal energy. There, a silicone heat transfer fluid reaches a temperature of 750°F and is used, through a centrally located heat exchanger, to drive a steam turbine and alternator. Low temperature steam, extracted from the turbine midstage, is used for pressing the manufactured knitwear, and low pressure exhaust steam is used to produce chilled water for the air conditioning.

Following a checkout period, a comprehensive series of 29 tests characterizing the performance of the Total Energy System was conducted by Georgia Power and Sandia National Laboratories personnel. This test program was successfully completed in December 1984. While several minor improvements to the system are now being made, normal operation is expected to resume in March 1985. At that time DOE's formal participation in the project will be concluded and title to the system will be transferred to Georgia Power. Georgia Power plans to continue to operate the system on a daily basis.

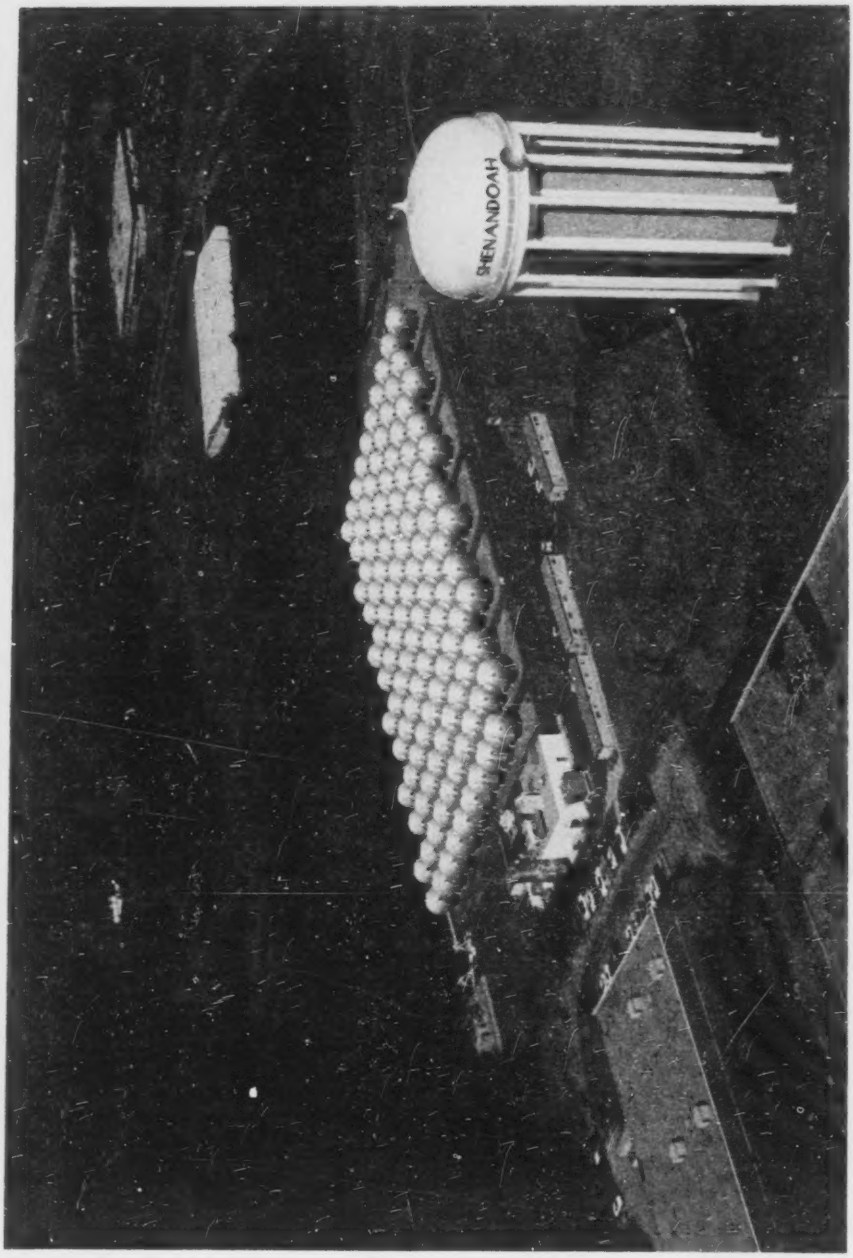

SHENANDOAH

Figure 4 - Shenandoah Total Energy Project

A 4.9 MWe central thermal plant using 700 dish concentrators was installed in Warner Springs, California in 1984. Each concentrator consists of 24 five foot diameter circular membrane reflector facets using a polymer reflective surface. Steam is generated at the focal point in the outer 580 dishes and flows through insulated, manifolded piping to the inner field of 120 dishes where it is superheated to 750°F at a pressure of 600 psi. The project was financed under a limited partnership utilizing the energy tax credits and sold for an announced price of $3780/kWe. The project is pictured in Figure 5.

Linear Trough Systems

The Linear Trough sector comprising parabolic troughs and fresnel lens concentrators is continuing its technology development towards commercialization. This sector has realized the best generational growth since 1977 due to its modularity of design and the lower concentration ratios that reduce the relative technical challenges. Several initial commercial projects have been introduced, including the privately financed 13 MW SEGS-I project at Barstow, California. This is the largest solar thermal technology plant in the world. The entire sector will be hard pressed to achieve future commercial sales if the energy tax credits expire on December 31, 1985. Thus, the engineering efforts of the sector will need to supplant with capital cost reducing innovations the cost reduction benefits supplied by the energy tax credits. In essence, component development will be required along with a new generation of parabolic trough or linear fresnel modules.

One example of remaining component development requirements concerns seals. Industry developed an effective and low cost evacuated receiver concept in 1984 with partial funding from Sandia. This concept employs conventional glass-to-metal seal techniques. Through proper selection of the readily available metal bellows material and its configuration, a reliable longlife seal is achieved with conventional receiver glazings. A full scale, short-length test section has been fabricated and supplied to Sandia for continued testing of the concept.

This receiver configuration provides a savings in the cost of installed trough systems of from 5.0 to 9.5%. The higher savings corresponds to higher operating temperatures--up to 550°F. Based on the success of this configuration and the savings in installed system cost, industry is currently negotiating with Sandia to fabricate full-length (20ft.) receivers for test and evaluation at Sandia.

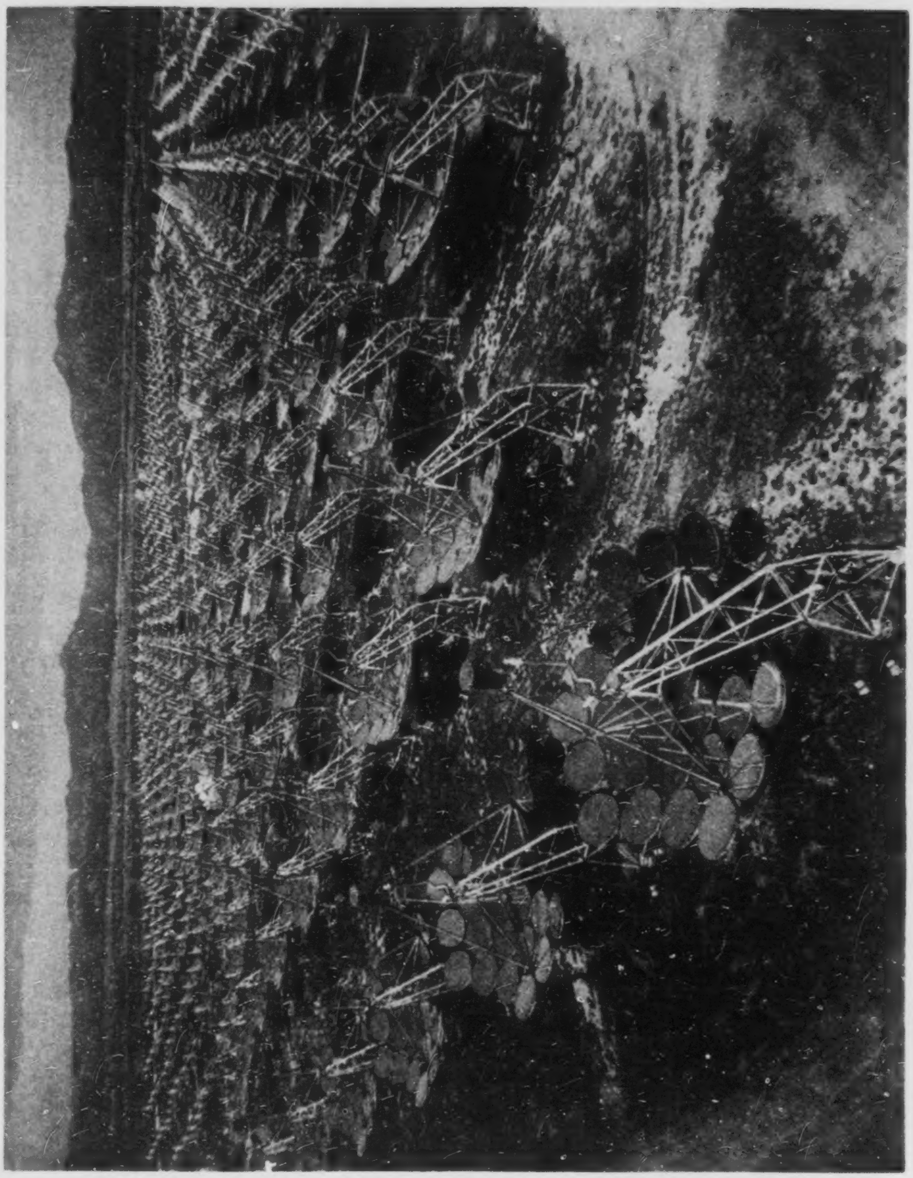


Figure 5 - 4.9 MWe Parabolic Dish
Central Thermal Project

In the research field for parabolic troughs, the program has been centered on the Modular Industrial Solar Retrofit Project.

The Modular Industrial Retrofit Project resulted in the development of five solar thermal, line-focus, industrial process steam systems. Qualifications test systems, representative of full-size systems in all but the size of the collector field, were manufactured, installed, and tested. The modular nature of the systems will minimize design and manufacturing costs for commercial installations. The systems can be installed in retrofit applications at many industrial plants that use saturated steam at pressures up to 250 psig.

As a result of the test phase of the project, the ability of these systems to produce energy at rates close to design predictions has been demonstrated, whereas in the past many systems have failed in the field to produce energy at rates predicted by laboratory testing.

In addition to these system tests, approximately twenty-five components have been developed, installed, and evaluated on the test systems. The goal of component development and testing has been to improve the reliability and performance of these systems. Many of the components were developed and supplied by industry at their expense, although testing has been funded by the Department of Energy. Among the outstanding components which have been developed and demonstrated are rotary joints which couple the heat transfer fluid piping on the rotating collector to the stationary piping manifolds. A DOE-developed process for applying anti-reflective coatings to collector receiver glazings has also been demonstrated, and improvements of from 8 to 18% in collector efficiency have been measured.

The Modular Industrial Solar Retrofit project is essentially complete, and industry has installed some privately-financed industrial systems; however, with the present low energy prices, there is now little market for these systems. In the meantime, industry continues to show interest in refining their products and is taking advantage of DOE-funded R&D and test facilities to supplement their very limited budgets for continued development.

Funding Issues For Distributed Receivers

The Administration's budget for distributed receivers is not reflective of the technical success to date or the challenges of the future. SEIA believes that $13M rather than $8.4M should be authorized in FY 86.

The parabolic dish and the parabolic trough engineering sectors have made substantial technical progress in both laboratory and field tests, including 18 MW's of early commercial systems. The results of these activities clearly indicate that the efficiencies and technology are on the right path and that the financial advantages to installing the systems on a module basis is a tremendous attribute. The benefits of modularily extend into research as well.

The Vanguard parabolic dish program cost DOE $2.8M to design, build and test a module, all within a 28 month period. Private industry efforts using the same heat engine designed and built another system within fourteen months. The next generational growth will not be as rapid or as inexpensive. The concentrator program has been initiated but testing all three designs plus selective component development will exceed the $850,000 for Innovative Concentrator Development and $1.4M for Testing and Evaluation.

The importance of heat engine research is properly noted in the Administration's budget. The strongest candidates for heat engine development are the NASA funded 25 kW free piston Stirling engine and a privately funded swashplate Stirling engine. Both possess the characteristics of high efficiency, long life and low operation and maintenance expense. The funding of heat engine development will be an expensive, time consuming, high risk and high payoff proposition for DOE and private industry. The Administration's budget seeks to develop a heat engine development and analysis program with $2.3 million in FY 86 when the proper amount should be $3.5M. The parallel efforts of photochemical and thermochemical research ($1M) and Transport and Storage ($1.2M) represent the minimum level of federal funding to these two long range areas.

Besides the heat engines, research is needed for the heat receivers. The needs for heat pipe and hybrid receivers have been adequately analyzed and the conclusions drawn are that these systems will extend the life, improve the economics and expand the market for parabolic dish systems. $2.0M rather than $1.2M should be spent in FY 86 for heat receivers.

Continued utilization of distributed receiver test facilities, including Shenandoah and the Crosbyton Hemispherical Bowl, is valuable to the overall program. As a general rule, SEIA supports the continued operations of significant module and system level experiments that contribute to the advancement of the State of the Art.

Research

The basic research program for Solar Thermal has realized significant accomplishments during the past year, but the program will require a continued interaction between private industry and SERI if this research is to become fruitful. Industry historically operates on a shorter time frame than academic and national laboratory schedules, but the integration of real world system specifications and the research community is necessary. The past year marked the most improvement in this area and further efforts will continue to be necessary in order to achieve maximum utilization of the federal research effort. Two examples of highly supported research efforts are the stretched polymer membrane work, and the solar detoxification of hazardous chemical wastes.

Silver/Polymer Reflectors for Solar Thermal Concentrators

Concentrators present the major opportunity for reducing the costs of solar thermal systems since they account for 40-60% of the system installed cost. At the present time, the most effective concentrators use silvered glass reflectors. They are efficient but brittle, requiring a heavy structural support system. The cost of glass-based concentrators is therefore increased because of the structural rigidity needed to prevent breakage. Consequently, in order to reduce concentrator cost -- and thereby reduce the system's capital and life cycle costs -- the Solar Thermal Technology (STT) Program strives to develop a high reflectivity, low-cost, lightweight, durable reflector material.

Silver/polymer reflector films -- investigated for three years in the Solar Thermal Research Program -- show very high promise for use in solar thermal concentrators. They offer the potential advantages of low weight, low cost, very high specular reflectivity, greater design flexibility and improved durability (compared to silvered glass reflectors) in the solar thermal operating environment. In addition, they have much greater reflectivity than the aluminized reflector materials that are now available commercially.

The silver/polymer research is aimed at developing reflector films having the following properties:

- Reflectance of at least 90%
- Specularity of 2.0 milliradians
- Useful life of at least 5 years
- Cost of $1.50/square foot.

If the research is successful, it will be possible to reduce greatly the costs of concentrators -- heliostats, dishes, and troughs -- thereby greatly reducing the system installed cost and life cycle cost of solar thermal systems.

As a result of research to date, SERI has identified, tested and evaluated three promising silvered polymers that show great promise in meeting STT Program requirements and objectives:

- Silvered polymethylmethacrylate (PMMA)
- Silvered polyacrylonitrile (PAN)
- ECP-300 (an experimental silver/polymer film produced by The 3M Company based on PMMA).

In addition, SERI has identified, tested and evaluated several additives that can protect transmitting polymers against UV degradation, oxidation, and environmental exposure.

Current research is aimed at increasing the reflectivity and specularity of silver/polymer films and at assessing their long-term durability in the solar thermal operating environment.

Solar Detoxification of Hazardous Chemical Wastes

Solar thermal energy has the potential to help solve the national problem of converting hazardous chemical wastes to substances which are environmentally acceptable. Present thermal disposal methods involve incineration, which uses significant quantities of fuel for the conversion of hazardous wastes. Solar thermal conversion of hazardous wastes has potential to be both more efficient and more cost-effective. Concentrated solar energy is expected to have both photolytic and thermal effects on the illuminated hazardous wastes. Direct absorption of solar photons could excite molecular bonds to a higher energy level where they will either react directly or be much more amenable to thermal reaction at a lower temperature than if no photolytic effects were present. In effect, the solar photolytic effect lowers the energy of activation of the waste detoxification reactions, making them more efficient at a lower temperature. Further, with solar detoxification, the need of auxilary fuel will be minimized, particularly for solar energy-fossil fuel hybrid systems.

DOE, via the SERI research program, has funded two significant research projects in this area. The University of Dayton is investigating the fundamental chemistry of hazardous waste destruction reactions. The researchers are specifically determining photolytic and thermal efficiencies for a wide range of materials, such as PCBs, to identify probable engineering feasibility, required experimental research and reactor types.

Research into the use of solar thermal energy to detoxify hazardous wastes has potential to impact significantly the solution of a national problem.

The Administration FY 86 Research request is approximately $6M, down from $7.4M a year ago. SEIA advocates $11.0M for research including the area supporting innovative concentrators, materials, storage and controls. The research program is definitely the one area that should be growth oriented and capable of providing multi-year funding commitments to the universities and research centers of excellence.

Conclusion

Solar Thermal Technologies have made significant technical and economic advancements during the past twelve months and the support of the House Science & Technology Committee has resulted in U.S. private industry assuming a world leadership position. Early commercial projects were attempted under the favorable financial conditions of the existing Energy Tax Credits. Some succeeded in gaining financing while others failed. Failures were attributed to the softening oil prices and the potential expiration of the Energy Tax Credit at the end of 1985. Experts in this field agree that the technical results in cost reductions, conversion efficiencies and operation and maintenance experience indicate that the central and distributed receiver technologies are capable of delivering electrical, mechanical, thermal or chemical energy in economically viable and technically feasible forms in the unsubsidized energy market that will characterize the next decade. The bridge to that future is the continued federal cost sharing with private industry and strong basic research at SERI and the universities. The technical accomplishments to date, the economic and public policy attributes and environmental benefits warrant the support of a $38.5M Authorization.

1986 DEPARTMENT OF ENERGY AUTHORIZATION

THURSDAY, MARCH 7, 1985

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Development and Applications,
Washington, DC.

The subcommittee met, pursuant to recess, at 2:09 p.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the committee) presiding.

Mr. Fuqua. The subcommittee will be in order.

Today we complete our hearings on the fiscal year 1986 authorization request for conservation and renewable energy. It gives me a great deal of pleasure to welcome our colleagues, our witnesses and guests to review the conservation programs.

Today we will deal with two very successful programs that have received a great deal of attention from our committee, the Building and Community Systems and Industrial Energy Conservation Programs.

The Building and Community Systems R&D Program has sponsored research which has led to the development of new building technologies and better understanding of the complex interactions among building components and systems. We will be receiving comments on the fiscal year 1986 budget request for Building and Community Systems, and we will be interested how the private sector is working with DOE and how they are using the R&D resulting from DOE activities.

The Industrial Energy Conservation Program examines ways to improve efficiency in industrial processes and utilize waste heat, and materials that would otherwise be discarded.

It is one of the only programs in the U.S. Government which funds research aimed at improving the productivity and competitiveness of U.S. industry.

We look forward to the second panel, to hearing from our outside witnesses regarding recent trends in foreign R&D, progress in the thin-strip casting project and recent innovative steel initiatives and the industry energy conservation program in general.

The first panel will be on buildings conservation. We have back again Mr. David Webb, who was here yesterday. Dave, you spend a lot of time up here. [Laughter.]

We will also hear from Mr. Orin Zimmerman, technical director of energy management and utilization of EPRI; Mr. Frank Coda, executive director of ASHRAE; and Mr. Thomas Vonier, chairman of the AIA Research in Design 85 Conference of the American Institute of Architects.

As is the custom of the committee, if you wish to make your formal statements part of the record and summarize, that will certainly be acceptable.

David, we are pleased to begin with you.

PANEL 1: BUILDING CONSERVATION

STATEMENT OF DAVID O. WEBB, SENIOR VICE PRESIDENT, POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE, WASHINGTON, DC

Mr. Webb. Thank you, Mr. Chairman.

I will summarize for the record.

I appreciate the opportunity to appear before you today to discuss GRI's views and fiscal year 1986 budget recommendations for gas-related research in the Department of Energy's conservation programs.

Within the gas industry's overall recommendation of $40 million for long-term gas research in conservation, GRI is recommending a core program of $15 million for research in DOE's Building and Community Systems Program and $12 million for industrial programs in fiscal year 1986.

Central to this $27 million recommendation for a DOE core program is the fact that GRI is planning to fund $34 million in 1986 for near-term research in these same program areas.

The urgency in establishing a consistent Federal policy of providing adequate funding for long-term research on the efficient utilization of gas is evident when you examine where the Nation will obtain its energy supplies during the next 25 years. Both private and Federal forecasts agree that the United States will continue to rely on oil and gas for over 60 percent of our energy in the year 2000, and approximately 40 percent in the year 2010.

Since, for today and for the foreseeable future, over 40 million families will continue to use gas, research to increase the efficiency of its usage must be a national priority.

The current deliverability surplus and softening of world oil markets provides us the opportunity to pursue this critical technology development in an orderly fashion rather than on a crash basis. While we have the time, we must seize this opportunity to strengthen our domestic energy potential.

In the past 4 years, Congress has recognized the need for a long-term DOE program in efficient utilization of gas and has appropriated approximately $20 million each year for this research. The gas industry is seeking a continuation of this trend in the fiscal year 1986 DOE budget.

To balance the proposed long-term DOE program, GRI will propose to its board of directors in April a 1986 budget of $164 million, which includes $70 million for research on efficient utilization of gas. Moreover, GRI's near-term research, which accounted for less than 40 percent of our R&D budget in 1981, in 1985 accounts for 80 percent of the budget.

This demonstrates that the natural gas industry has assumed responsibility for funding the near-term aspects of efficient utilization research and development. We have increased our budget over the past 4 years for this research from $39 million in 1982 to a level of $70 million in 1986.

We feel the administration should enter into a partnership with the gas industry by carrying out its responsibility of continuing the critical long-term, high-risk research at a funding level of $27 million in fiscal year 1986.

I would now like to discuss two important long-term programs in efficient utilization research on gas that are consistent with a balanced policy, have previously been supported by this committee, and require continued Federal funding.

In the Building and Community Systems Program of DOE's conservation, GRI is recommending $11 million in 1986 for a joint gas industry-DOE program on gas heat pumps and prime movers. Specific technology-based research is needed on advanced components, engines and systems necessary to produce a competitive heat pump for residential and commercial markets by the early 1990's.

Achieving this goal requires a joint DOE-gas industry program with funding of approximately $25 million per year. To meet the program goals and schedules requires an expanded DOE program of $11 million in fiscal year 1986, which GRI will match with a level of $13.1 million in 1986 for the near-term aspects of the joint program.

The gas heat pump not only offers increased efficiency over existing gas-fired space conditioning equipment but also can provide heating and cooling in a single unit. Heat pumps can provide both heating and cooling in colder climates at a lower overall cost than would otherwise be possible.

Commercial as well as residential heat pumps could also contribute to load leveling and reducing peak demand for the electric utilities in the summer, when the demand for gas is at its lowest, thereby reducing overall operating costs for both electric and gas utilities.

Gas currently provides winter heating comfort for more than 40 million families in the United States. Of the approximately 4 million commercial buildings in the country, over 55 percent of them have natural gas hookups, and 50 percent use gas for space heating. Therefore, developing a heat pump program for the residential/commercial market should be a top national energy priority.

The four major elements of the proposed joint DOE/GRI comprehensive gas heat pump program are: system development, concentrating on the R&D for an entire heat pump system or a major component such as an engine; new concepts evaluation, consisting of evaluating promising technical approaches at a very early stage of development; supporting research, consisting of fundamental research in basic processes, phenomena and materials, generic component development, and cross-cutting research on new analytical tools to examine the competitiveness of the system; and, finally, systems analysis focusing on studies to set generic R&D goals and identify specific components and subsystems that can be improved to lower the overall cost of the systems.

We are essentially proposing a program structure and a funding similar to the Japanese development that is currently underway in small gas engine heat pumps. As of 1984, seven systems that were jointly started with the Japanese Ministry of International Trade and Industry have been narrowed to four gas heat pump systems which are going through preproduction and field test evaluation.

MITI provided approximately 50 percent of the money or $50 million over a 3-year period, with the gas utilities and manufacturers in Japan providing approximately the other 50 percent of the money. GRI is proposing a similar funding profile with DOE.

Specifically, in the DOE 1986 budget we are recommending that $5.5 million be devoted to system development with DOE concentrating on the absorption and the Stirling engine technology, while GRI concentrates on the IC engine technology and field testing of the prototype units.

We are proposing $4 million in supporting research, again with DOE concentrating on the longer term Stirling engine development and GRI concentrating its efforts on the absorption heat pump.

We are, overall, proposing a program of $11 million of DOE funding to be matched by $13 million of GRI funding. We feel this joint program gives us a real opportunity to develop a viable, competitive gas heat pump in the United States by the early 1990's.

One other area, Mr. Chairman, I would just briefly like to touch on, though it is not of this panel, is that in the area of industrial cogeneration, GRI is recommending a DOE program of $12 million. GRI in its budget has $7.3 million for near-term research, primarily pointed toward packaged cogeneration systems that we are demonstrating with hospitals and restaurants.

There is a longer term need for a DOE program concentrating on industrial size induction generators, less expensive waste heat boilers, improved natural gas compression equipment, and improved heat rate combustion turbines and other advanced prime movers.

In summary, Mr. Chairman, a viable, consistent DOE core program of long-term gas research in efficient utilization is essential as one central element of a balanced Federal energy policy.

GRI recommends a DOE fiscal year 1986 budget for long-term gas-related research in its conservation program of $27 million. This recommendation essentially would continue programs approved by this committee and Congress for gas-related research over the past 4 years and will be supplemented by $34 million of near-term research by GRI in these same program areas.

That completes my testimony, and I will be happy to respond to any questions you may have now or at the end of the panel.

[The prepared statement of Mr. Webb follows:]

STATEMENT OF DAVID O. WEBB, SENIOR VICE PRESIDENT
POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE
BEFORE THE SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
MARCH 7, 1985

I appreciate the opportunity to appear before you today to discuss the Gas Research Institute's (GRI) views and FY 1986 budget recommendations for gas-related research in the Department of Energy's (DOE) Conservation programs. Within the gas industry's overall recommendation of $40 million for long-term gas research in conservation, GRI is recommending a core program of $15 million for research in the DOE Building and Community Systems Program and $12 million for industrial programs in FY 1986. Central to this $27 million recommendation for a DOE core program in long-term gas-related research is the fact that GRI is planning to fund $34 million in 1986 for near-term research in the same program areas. Today my testimony will concentrate on the GRI recommended programs, many of which are cofunded and coordinated with GRI and other industrial firms.

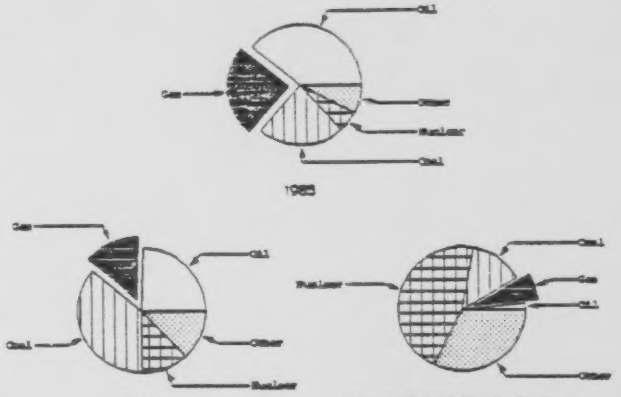
GRI is an independent, not-for-profit scientific research organization that plans, manages, and develops financing for a cooperative research and development (R&D) program for the mutual benefit of the gas industry and its present and future customers. The R&D program is implemented through contracts with research organizations, engineering and other professional service firms, universities, energy companies, and manufacturers. Funding for the GRI R&D program is provided primarily through regulated sales of natural gas. An R&D funding unit, approved annually by the FERC, is incorporated into the cost of gas of GRI's 31 interstate pipeline company members. GRI members, subject to appropriate state approvals, also apply a similar charge to their intrastate and direct industrial sales. This funding arrangement enables GRI to conduct a truly comprehensive R&D program at a cost to the typical residential gas customer (in 1984) of about $1.40 per year. Even though GRI is not a government contractor and does not accept federal funds, GRI cofunds and coordinates many of its research programs with DOE; therefore, the actions of Congress on the FY 1986 DOE budget have a direct impact on the gas industry's research program.

NEED FOR REVISED FEDERAL ENERGY R&D PRIORITIES

The urgency in establishing a consistent federal policy of providing adequate funding for long-term research on the efficient utilization of gas is evident when you examine where the nation will obtain its energy supplies during the next 25 years. Both private and federal forecasts agree that the U.S. will continue to rely on oil and gas for over 60 percent of its energy needs in the year 2000 and approximately 40 percent in 2010. Since for today and for the foreseeable future over 40 million families will use gas, research to increase the efficiency of its usage must be a national priority.

A revealing illustration of the imbalance between DOE funding priorities and the actual research needs of the nation is to contrast DOE FY 1985 R&D budgets by energy resource compared to current and future energy resource utilization. As shown, DOE would assign only 20 percent of its funding to fossil fuels and conservation research, yet the U.S. is projected to meet 75 percent of its energy needs in the year 2010 from oil, gas, and coal. It is impossible to have a balanced national energy program without a sharp shift in research funding priorities.

U.S. ENERGY NEEDS



1985

2010

1985 DOE R&D Fuels Budget
(Excluding weapons and basic research)

DOE FY 1986 ENERGY R&D FUNDING PRIORITIES

While a balanced energy policy would establish a proportionate relationship between R&D funding and the actual production of U.S. energy resources, DOE has proposed an unbalanced budget again in FY 1986. The funding proposed for weapons activities is three times the proposed energy R&D budget. The budget for nuclear energy research is so much larger than the combined DOE research programs in fossil and conservation research that it totally makes a myth of a balanced energy program.

DOE must provide a stable funding base for long-term, high-risk gas-related research while the regulated gas industry is increasing its near-term research funding. In contrast to the need for a balanced research policy, the proposed FY 1986 DOE Conservation research program is $145 million--down approximately 20 percent from the FY 1985 appropriated level of $176 million. The proposed gas-related research funding in the total DOE Conservation R&D program is only $14 million in FY 1986. In summary, the Administration's proposed FY 1986 conservation research budget is not consistent with a rational energy policy and certainly does not provide stable funding for a core program of long-term gas research.

National energy policy as modified by Congress has stressed and encouraged development of ample supplies of domestic energy resources and the more efficient use of energy to reduce the dependence on insecure oil imports. A central element of this policy has been congressional initiatives to restore funding for critical conservation research programs in DOE. Maintaining adequate program funding is critical if the U.S. is to successfully develop the full potential of our vast domestic energy resources.

NEED FOR DOE FUNDING OF NATURAL GAS R&D

Natural gas will continue to maintain an important role in a highly competitive energy mix throughout the remainder of the century. The GRI 1984 Baseline Projection of U.S. Energy Supply and Demand shows that the role of gas even after the year 2000 will remain a central element in meeting U.S. energy demands.

GAS DEMAND BY SECTOR

1984 GRI Baseline Projection

(Quads)

	Actual 1983	1990	2000	2010
Residential	4.6[a]	4.5	4.3	3.9
Commercial	2.6[a]	2.8	3.5	4.5
Industrial	6.7	7.7	8.3	6.2
Electric Generation	3.0	3.9	2.6	2.1
Transportation	0.6	0.7	1.0	1.1
TOTAL[b]	17.5	19.6	19.7	17.8

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[a] Historic Energy Information Administration (EIA) statistics for 1983 do not disaggregate data for the residential and commercial sectors.

[b] Includes 0.1, 0.3, and 0.8 quad of synthetic gas from petroleum and coal in 1990, 2000, and 2010, respectively.

Establishing the technology base and developing the processes and equipment to use gas most efficiently in the residential/commercial and industrial sectors requires a lead time of 10 to 15 years. The current gas deliverability surplus and softening of world oil prices provides us the opportunity to pursue this critical technology development in efficient utilization in an orderly fashion rather than on a crash basis. While we have the time, we must seize this opportunity to strengthen our domestic energy potential. To do so, GRI is recommending $27 million for a core program of gas-related research in the DOE Conservation budget. Fifteen million dollars is for research in DOE's Building and Community Systems Program, and $12 million is for industrial utilization research. This long-term DOE core program will be supplemented by the $34 million GRI budget in 1986 which focuses on near-term efficient utilization research.

GRI'S RECOMMENDED FY 1986 DOE LONG-TERM
GAS-RELATED CONSERVATION RESEARCH FUNDING
($ Millions)

Gas Heat Pump and Prime Mover	$11.0
Industrial Processes	12.0
Building Systems/Indoor Air Quality	2.0
Desiccant Cooling Systems	2.0
TOTAL	$27.0

In the past four years, Congress has recognized the need for a long-term DOE program in the efficent utilization of gas and has appropriated approximately $20 million each year for this research. The gas industry is seeking a continuation of this trend in FY 1986.

GAS RESEARCH INSTITUTE'S 1986 BUDGET

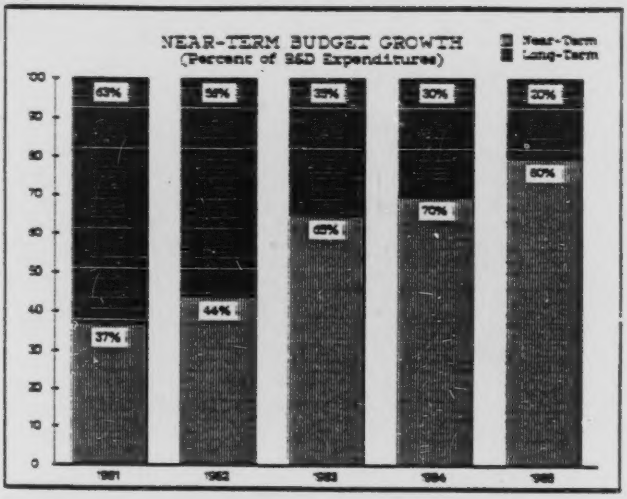
In contrast to the DOE policy of reduced funding for long-term gas research in efficient utilization, the gas industry has responded rapidly and impressively to federal R&D policy by funding more of its own near-term research. GRI will propose to its Board of Directors in April a $164 million 1986 budget which includes $70 million for research on the efficient utilization of gas. The efficient utilization programs include $19 million targeted for industrial applications and $41 million directed at residential/commercial energy systems.

Recognizing national energy R&D policy is a major factor influencing the GRI R&D program, the GRI Board of Directors, with input for GRI's advisory committees, adopted the following strategy in response to the evolution of government energy R&D funding policy over the past four years:

- o GRI should assume a leadership role in near-term gas-related R&D.
- o GRI should reduce funding for long-term research but continue to seek coordinated funding with DOE where appropriate.

- o GRI should expand its already extensive efforts to obtain coordinated funding from industry.

As the level of federal funding and support has declined since 1981, essential near-term gas research was no longer funded by DOE. GRI responded to this by cancelling or deferring some of its own projects with a longer-term payback and concentrating its limited resources on projects with a more immediate return to the industry and ratepayers. This resulted in a radical change in the direction and makeup of GRI's program. While near-term research accounted for under 40 percent of GRI's R&D budget in 1981, it accounted for 80 percent of the 1985 budget.



The natural gas industry has assumed responsibility for funding the near-term efficient utilization research and development by increasing its budget for these research activities over the past four years from of $39 million in 1982 to $70 million in 1986. The Administration should enter into a partnership with the gas industry by carrying out its responsibility of continuing the critical long-term, high-risk research at a FY 1986 funding level of $27 million.

GRI EFFICIENT UTILIZATION RESEARCH BUDGET
($ Millions)

	Actual 1982	Planned 1986
Environment & Safety	$ 1.75	$ 4.70
Residential/Commercial	28.00	41.56
Industrial Utilization	7.95	19.34
Basic Research/End-Use	1.20	4.05
TOTAL	$38.90	$69.65

RECOMMENDED DOE FY 1986 LONG-TERM GAS-RELATED RESEARCH PROGRAM IN EFFICENT UTILIZATION

Discussed below are several important long-term programs in efficient utilization gas research that are consistent with a balanced energy policy, have been supported previously by this Committee, and require continued federal funding.

Conservation/Building and Community Systems

	FY 1985 Appropriation	GRI FY 1986 Recommendation
Gas Heat Pumps and Prime Movers	$4.5M	$11.0M

In a study done by the Energy Research Advisory Board, it was reported that "the manufacturing sector is so diverse that individual companies cannot capture the benefits of conservation R&D"; therefore, the federal research role becomes critical. Specific technology-based research is needed on advanced components, engines, and systems necessary to produce a competitive heat pump for residential and commercial markets by the early 1990s. Achieving this goal requires a joint DOE/gas industry program with funding of approximately $25 million per year. To meet the program goals and schedule requires an expanded DOE program of $11 million in FY 1986 which GRI will match with $13.1 million in 1986.

The operating principle of heat pumps in the same as that of a common refrigerator, freezer, or air conditioner--they remove heat from some source and "pump" it to its destination. By extracting heat from the outside air and transferring it to the indoor space, heat pumps can actually supply more thermal energy than is contained in the fuel they use, even on cold days. The heat pump's cooling effect is accomplished by reversing this process. Currently, only mechanical heat pumps driven by electric motors are available for residential space conditioning.

The gas heat pump not only offers increased efficiency over existing gas-fired space conditioning equipment but also can provide heating and cooling in a single unit. Heat pumps can provide both heating and cooling in cold climates at a lower overall cost than would otherwise be possible. Commercial as well as residential heat pumps could also contribute to load leveling and reduction in peak demand for both natural gas and some electric utilities, thereby reducing operating costs.

Gas currently provides winter heating comfort for more than 40 million families in the United States. In the approximately 4 million commercial buildings, over 55 percent have natural gas hookups, and 50 percent use gas for space heating. Therefore, developing a gas heat pump for the residential/commercial markets should be a top national energy priority. GRI has been working with DOE over the past three years to develop a cooperative research program. GRI is concentrating on the more near-term aspects of the research, and DOE is focusing on the longer-term advanced component and engine research necessary to develop a cost-competitive gas heat pump system.

The joint DOE/GRI program covers two broad categories of gas heat pump research: mechanical heat pumps and absorption heat pumps. Mechanical systems use gas engines instead of electric motors to drive a system in which a refigerant vapor is alternately compressed and expanded in a continuous cycle. Absorption systems use the heat from gas combustion to sustain a fluid separation cycle employing evaporation and absorption.

Absorption heat pumps offer the potential advantages of higher reliability and lower maintenance costs than the mechanical systems since the absorption system uses relatively few moving parts. However, a mechanical system using an advanced gas engine has the potential to achieve a higher efficiency and thereby to increase overall cost-competitiveness. Therefore, GRI has adopted a strategy that calls for development of a first-generation heat pump for market introduction by 1990 and an advanced heat pump using new engine technology for introduction in the mid-1990s. Internal combustion engine technology and absorption technology are both being investigated for the early-entry heat pump. Stirling engine technology is GRI's primary approach to attaining its R&D goals for an advanced residential heat pump by the mid-1990s.

Reaching these goals will require a cooperative DOE/GRI research program. Although there are many difficult technical issues that must be addressed in each of these concepts, a common barrier is the first cost. The unit cost must provide a payback within in at least five years, and the equipment must have a service life of approximately 40,000 hours. Therefore, to increase the likelihood that this kind of equipment will be available to U.S. homeowners and commercial building owners and operators in a timely manner, DOE and GRI have identified a national R&D program to advance this technology. The guiding principles are:

- to pursue multiple parallel options,
- to pusue near-term concepts with modest performance goals dictated by market considerations,
- to develop advanced, long-term concepts with high-performance characteristics through research on components such as new engine concepts,
- to transfer technology from near-term Japanese concepts to U.S. programs,
- to focus technology transfer to industry on the GRI elements of the program, and
- to maintain a rigorous economic evaluation system throughout the program development period.

Most of the technologies being developed and that eventually will be introduced to the market are major departures from current gas equipment. The current knowledge in the U.S. is very narrow; therefore, in addition to heat pump system development, a broad-based effort in advancing fundamental knowledge is needed. Some of this research conducted at leading universities should be generic and should focus on basic phenomena.

The four main elements of the joint DOE/GRI comprehensive gas heat pump program are:

- System Development concentrating on R&D for an entire heat pump system or major component.
- New Concepts Evaluation of promising technical approaches at a very early stage of development.
- Supporting Research consisting of fundamental research in basic processes, phenomena, and materials; generic component development; and cross-cutting research on new analytical tools.
- Systems Analysis focusing on studies to set generic R&D goals and identify specific components and subsystems improvements.

These four program elements must be funded at a minimum level of effort or a critical mass if a fully competitive gas heat pump is to be available by 1990.

The program structure and funding recommendations are similar to the Japanese development effort on small gas engine heat pumps. As of 1984, four heat pump systems under joint development with Japanese industry were undergoing preproduction and field test evaluation. Approximately 50 percent of the development funds are provided by the Japanese Ministry of International Trade and Industry (MITI), with the other 50 percent coming from the participating utilities and manufacturers. GRI is proposing a similar funding profile with DOE. DOE would provide $11 million in FY 1986, and GRI would provide $13.1 million. The funding would support the research program outlined in the following table.

HEAT PUMP BUDGET REQUIREMENTS SUMMARY/FY 1986
($ Millions)

		DOE	GRI	Total
SYSTEMS DEVELOPMENT		$ 5.5	$10.2	$15.7
Absorption	$5.1			
Stirling	5.6			
I.C. Engine	4.0			
NEW CONCEPTS EVALUATION		0.8	0.4	1.2
SUPPORTING RESEARCH		4.0	1.9	5.9
Absorption	$2.0			
Stirling	2.4			
I.C. Engine	1.0			
Other	0.5			
SYSTEMS ANALYSIS		0.8	0.6	1.4
TOTAL ANNUAL BUDGET		$11.1	$13.1	$24.2

The research funding should concentrate on two or three concepts for the commercial buildings market. Also, research should be conducted on adding domestic water heating to the commercial-size gas heat pump. Initial studies indicate the use of the engine reject heat to heat water provides a useful application during the summer months that could result in a 20 percent increase in overall system performance.

Multiple technological options are needed for the residential market to solve the critical problems of unattended performance, first cost, and reliability. The technology concepts being pursued include double-effect and dual-cycle absorption heat pumps and heat pumps driven by reciprocating internal-combustion engines, rotary internal-combustion engines, and free-piston Stirling engines. The following table outlines the COP targets for each of these concepts.

COP TARGETS OF GRI-SUPPORTED HEAT PUMP CONCEPTS

Residential	Heating	Cooling
Dual-Cycle Absorption	2.00	1.10
Double-Effect Absorption	1.55	0.85
I.C. Engine (Reciprocating)	1.70	1.00
I.C. Engine (Rotary)	1.70	1.00
Free-Piston Stirling	1.80	1.10

Development of small internal-combustion engines for use in heat pumps would have many applications, primarily in cogeneration. Initial research has shown that the needed improvements in engine life, maintenance requirements, and controls are definitely achievable. Several attractive long-term technologies, specifically free-piston Stirling engines and free-piston internal-combustion engines, show potential. These are being developed as an element of the gas heat pump program and should be continued due to the early stage of development and high technical risk. Research needs to be conducted in the areas of dynamic component matching, improved high-temperature materials, ceramic development and application, seal technologies, heat exchangers, use of electronic engine controls, and high-temperature lubricants.

A viable U.S. gas heat pump and prime mover program requires a joint federal/gas industry effort with each funding $11 million to $13 million per year.

	FY 1985 Appropriation	GRI FY 1986 Recommendation
Desiccant Cooling/Refrigeration Systems	$0.0M	$2.0M

Today, the cooling needs of most small commercial buildings are being met with electric vapor compression air conditioners and heat pumps. However, in areas of the country that experience high humidity and in commercial buildings that have high internal humidity loads, the use of these systems to handle both the moisture (latent) and cooling (sensible) loads is often inefficient in terms of energy and equipment utilization. An alternate and more efficient approach is the use of an integrated gas-regenerated desiccant dehumidifier in conjunction with a smaller-capacity electric vapor compression air conditioner. Warm air from a gas burner is used to dry or regenerate the desiccant material which abosrbs or removes moisture and thereby handles the latent cooling load. An electric air conditioner meets the sensible load.

GRI is field testing the concept of an integrated gas desiccant/electric air conditioner in several supermarkets. A supermarket is a good application for such a system since the operation of freezer and cooler cases reduces the sensible load and leaves approximately one-half of the air conditioning load to provide dehumidification. Current systems result in oversized air conditioners which are operated at high load factors and low evaporative coil temperatures. The result is poor efficiency and high operating costs.

While GRI concentrates on these near-term integrated gas-electric systems, DOE should initiate research on more advanced gas desiccant systems. The research should have as its goal a total desiccant cooling system (no electric cooling components) in sizes from 10 to 20 tons. Key technology improvements are needed in reducing the size and cost of the desiccant wheel and heat exchanger components. Funding of $2 million is required in FY 1986.

	FY 1985 Appropriation	GRI FY 1986 Recommendation
Building Systems/Indoor Air Quality	$1.9M	$2.0M

DOE should continue its research efforts to develop inexpensive passive monitors for measuring indoor air quality at a relatively low cost. Efforts should focus on infiltration, ventilation, and air movement in buildings. The impact of reduced air exchange rates on indoor air quality is not well understood, and investigations are required to develop an accurate and reliable data base. The DOE funding of $2 million will be supplemented by a GRI budget of $4.1 million in 1986.

	FY 1984 Appropriation	FY 1985 Appropriation	GRI FY 1986 Recommendation
Industrial Cogeneration	$6.0M	$7.2M	$12.0M

Gas-fired cogeneration can supply both electrical and thermal energy service in a highly efficient manner. The enviromental and strategic benefits of gas-fired cogeneration are also significant, since efficient use of clean-burning gas from domestic sources decreases total emissions and helps reduce unacceptable dependencies on imported petroleum fuel supplies.

Energy conversion efficiencies in the 30 percent range, typical of equipment currently dominant in industrial and electric power-producing installations, are no longer economically competitive. Cogeneration of electricity or shaft horsepower and useful heat at overall efficiencies of 70 percent to 80 percent is possible through a coordinated federal/industry research program. New approaches that meet the combined thermal, shaft horsepower, and electrical requirements of an industrial facility are needed.

The technical potential for cogeneration has been estimated to be as much as 200,000 megawatts in a recent study by the Office of Technology Assessment. Much of this potential is in the industrial sector which continues to be the largest energy-consuming sector of the U.S. economy--accounting for approximatley 38 percent of total U.S. gas consumption in 1984. Despite the significance of natural gas use in the industrial sector, the potential for cogeneration has only begun to be realized recently. The major problem is to develop and build advanced systems with improved operating efficiencies and ease of maintenance. The DOE research should concentrate on developing advanced materials, components, and compressors to handle higher temperatures necessary to boost efficiencies.

GRI's research efforts are focused on the more near-term problems of demonstrating cost-effective packaged cogeneration systems for the commercial and light-industrial markets. GRI's industrial sector R&D program, with substantial technical and financial support from industrial equipment manufacturers and end-users, is structured to overcome the present constraints facing the industrial gas consumer. GRI is currently developing packaged cogeneration systems in sizes ranging from 50- to 1,000-kilowatt electrical output, with greater than 75 percent overall efficiencies at installed costs less than $1,000 per kilowatt for application in commercial buildings and multifamily dwellings. Last July an experimental packaged 500-kilowatt cogeneration system was started up at a hospital in Houston, Texas, where it is undergoing a one-year field test. This packaged system, designed and built under a cost-shared GRI contract by Martin Cogeneration Systems, is just one project in GRI's effort to target cogeneration packages at major groups of applications that share similar, fairly predictable energy requirements. GRI's proposed 1986 budget contains $7.3 million for these near-term cogeneration activities.

The longer-term need to be funded by DOE is to establish and conduct a parallel research program with emphasis on developing advanced materials and advanced heat transfer and thermodynamic and microprocessor concepts. These components and concepts must then be integrated into prototype units to allow industry to evaluate the effectiveness of the systems. This R&D will improve the cost-effectiveness, efficiency, reliability, and flexibility of cogeneration systems. The result is increased cost savings and expanding potential applications for gas-fired cogeneration systems. Improved components from this DOE-sponsored research can be integrated into both first- and second-generation packaged system. To this end, it is recommended that DOE consider development programs in the following areas:

- industrial-size induction generators for use with natural gas prime movers,
- less expensive waste heat boilers,
- improved natural gas compression equipment for combustion turbines,
- standardized grid interconnect systems for prepackaged industrial-scale systems, and
- improved heat rate combustion turbines and other advanced prime movers in the 2- to 10-megawatt class.

DOE funding of $12 million in FY 1986 is recommended.

SUMMARY

A viable, consistent DOE core program of long-term gas research in efficient utilization is essential as one central element of a balanced federal energy policy. GRI recommends a DOE FY 1986 budget for long-term gas-related research in its Conservation program of $27 million consisting of $11 million for gas heat pumps and $12 million for industrial cogeneration. This recommendation essentially continues the programs approved by Congress for gas-related research over the past four years and is supplemented by $34 million of near-term research by GRI in the same program areas.

This completes my testimony. I will be happy to respond to any questions the Members may have.

Table 1
GRI END-USE PROGRAM BUDGET
($ Millions)

Program	Actual 1984	Planned 1986
Residential/Commercial Heating and Cooling Systems	$ 5.7	$ 7.0
Residential/Commerical Heat Pumps and Prime Movers	10.0	13.1
Residential/Commercial Appliances	5.8	5.5
Building Systems Research	1.0	1.6
Cogeneration and Fuel Cells	22.9	12.8
CNG Applications	0.0	1.6
Indoor Air Quality and Emissions Control	3.8	4.7
Industrial Processes and Systems	14.0	19.3
Basic Research/End-Use	1.7	4.1
TOTAL	$64.9	$69.7

Table 2
GAS INDUSTRY FY 1986 RECOMMENDATIONS FOR DOE'S CONSERVATION PROGRAM
($ Millions)

Program Area	FY 1986 Recommendation
BUILDING AND COMMUNITY SYSTEMS	$15.0
Gas Heat Pumps and Prime Movers	
Desiccant Cooling Systems	
Building Systems/Indoor Air Quality	
INDUSTRIAL	12.0
CNG VEHICLES	5.0
GAS COMBUSTION/SELECT-USE RESEARCH	5.0
ADVANCED GAS TURBINE DEVELOPMENT	3.0
TOTAL	$40.0

Mr. **Walgren** [acting chairman]. Thank you very much.

Let's turn to Mr. Zimmerman.

STATEMENT OF ORIN F. ZIMMERMAN, TECHNICAL DIRECTOR, ENERGY UTILIZATION, ELECTRIC POWER RESEARCH INSTITUTE, PALO ALTO, CA

Mr. **Zimmerman**. Thank you, Mr. Chairman.

I am Orin Zimmerman, technical director, energy utilization, Electric Power Research Institute.

As previously commented on, my prepared testimony is made available for the record. However, I wish to highlight two or three items.

First of all, I would like to identify some important R&D needs to further enhance the efficient utilization of energy in the residential, in the commercial, and in the industrial sectors.

Second, I would like to identify roles and cooperation between the U.S. Department of Energy and the private sector.

There are major opportunities, national opportunities, for increasing the efficiency and the cost effectiveness of heating with the electric heat pump. Likewise, the other issue—which I recognize is for another panel—I will have a comment on the industrial productivity issue and the economic competitiveness with a large number of electrotechnology applications in materials production, metals fabrication, and process industries.

In addition to these two areas, there are other areas which I am sure are of interest to the committee, which will be covered probably in other hearings, including real opportunities in the use of the semiconductor, an application which we are beginning to see emerge in motor drives, et cetera.

We have programs in all of these areas, and we would recommend that DOE continue their support in these areas. By examining, I think you will agree you could increase the basic research component.

Now, I wish to comment on two specific electrotechnologies. The first one is the heat pump technology.

From a technical perspective, the full potential of the electric heat pump has not been realized. Today's high-efficiency systems operate at between 18 and 20 percent of the theoretical efficiencies.

The current private sector technology advancement efforts are inadequate for realization of this total potential as currently these efforts are directed at the near- and mid-term equipment and systems improvement, which has been paying off at an improvement rate of 2½ to 3 percent each year for the past decade.

There are desperately needed long-term research efforts beyond the reach of the private sector because of significant high-risk issues. The current EPRI heat pump program for the 1985–89 time period is based on a research and development budget of $20.8 million.

Our program includes limited proof-of-concept research, limited product development, and application research. It emphasizes the near-term R&D on the premise that the U.S. Department of Energy will sponsor the bulk of the basic and exploratory research to continue to build the needed base of understanding for the advanced systems.

Given a strong DOE program, the EPRI program can serve as the next step for the utilities to join in partnership in making the basic advances in development, working with the manufacturing industries and users in the private sector to accomplish the transfer of improved technology to commercial applications.

Now, within this general subject area of buildings, I would like to add something that I commented to and alluded to in my prepared testimony, but inasmuch as we made the segmentation the way that we did here today, I would like to add two other comments.

We totally endorse the findings of the Building Energy Research Workshop which was sponsored by the Committee on Science and Technology. This was published in May of 1983. There is one area I would like to call your attention to in that which is needed, and that is an indepth analysis of this indoor air quality issue. We need to examine most critically the role that conservation and weatherization play, if they play any role, in national health issues and the indoor air quality.

I would raise this report as what we feel is an excellent example of working with you and GRI and EPRI and others in the building industry in bringing forth and establishing a priority, and this issue is listed as critical in this report, and I would recommend that that be considered.

The second issue I would like to talk about specifically is the industrial area. The traditional energy-intensive industries which importantly include steel, aluminum, metals fabrication, and chemicals are under severe pressures from international competition. An acute need for productivity improvements has developed in order to maintain their continued viability and, in some cases, their survival in the world marketplace.

New and improved electric processes hold significant promise to deliver these urgently needed productivity and efficiency improvements. Now, quite often you find that a troubled industry does not have the ability to invest in the type of major R&D activities needed to provide for these technical advantages. Moreover, many of these are smaller companies for which there is not a homogeneous group that can speak for them and can aggregate together their needs.

We feel that this activity needs attention. EPRI is addressing this issue. We have a 5-year funding program in this area of $20.3 million. We feel that it will be important for you to address this system.

In my prepared comments, I give you a couple of examples. They are real examples dealing with not only the big systems, not only the big companies; but, for an example, the metals fabrication industry, essentially the standard classification codes 34 through 39 deal with 150,000 establishments. The majority of those establishments employ 20 people or less.

These are the bread and butter of our industrial sector. These are the people who supply the minute parts to the big industries. These people are left on their own as to how to survive in the competitive world. These are the people who are being threatened by imports of these products.

The total employment in this area in 1982 was 7.5 million. We are talking about a substantial employment base.

The dollar value of the shipments in 1980 was $676 million of homegrown investments. I just want to call that group of industries, who are not the big industries, but these are the people you find in the "mom and pop" shops, to your attention. They are run by small business enterprises.

Last, I would like to comment on the role that we think that, jointly, we can play, and more particularly to comment on roles for the U.S. Department of Energy.

The U.S. Department of Energy can greatly enhance the availability of innovative electrotechnology in the U.S. industry. Particular emphasis should be placed in the fundamental research which can feed into EPRI, its research and development application centers, and the other private sector commercialization centers.

Basic research in materials, in fluids, in tribology, electrochemical processes, along with the supporting work in advanced heat pumps for residential and commercial applications, new and improved electrotechnologies, will be a tool in achieving greater industrial productivity and will greatly strengthen the Federal partnership with the private sector.

We look forward to continuing our program planning in these important areas with the Department of Energy and other governmental agencies.

Thank you, and I will be willing to respond to any questions you might have later.

[The prepared statement of Mr. Zimmerman follows:]

STATEMENT OF ORIN F. ZIMMERMAN
TECHNICAL DIRECTOR, ENERGY UTILIZATION
ELECTRIC POWER RESEARCH INSTITUTE

TO THE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

MARCH 6, 1985

Mr. Chairman and Members of the Subcommittee:

I am Orin F. Zimmerman, Technical Director, Energy Utilization, for the Electric Power Research Institute. On behalf of EPRI, I would like to thank you for the opportunity to appear before you and to present our thoughts on some of the R&D needs in the efficient utilization of energy. EPRI was founded in 1972 by the nation's electric utilities to develop and manage a technology program for improved electric power production, distribution, and utilization.

Accompanying me is Mr. Gene Mannella, Deputy Director of the Washington Office. He can answer questions on the overall mission and objectives of EPRI's comprehensive research, development and demonstration programs.

In my testimony today I would like to emphasize two key issues:

1. Some of the important R&D needs in the efficient utilization of energy in the residential, commercial, and industrial sectors.

2. The roles and cooperation between the U.S. DOE and the private sector.

In prioritizing the R&D need we have relied on three premises as well as the recent trend of primary fuel consumption. The first premise is that there is a close relationship between gains in industrial production and industrial productivity on the one hand, and growth of electric energy use on the other. The second premise is that the use of electric energy provides a host of valuable and competitive energy services in the residential, commercial, and industrial sectors. These uses often rely on the unique form value of electricity that permits energy to be applied with superior efficiency, ease of control, and intensity. The third premise is that the productive uses of electric energy reduce the national dependence on foreign oil.

There are major national opportunities for (a) increasing the efficiency and cost effectiveness of heating with the electric heat pump, and (b) improved industrial productivity and economic competitiveness with a large number of electrotechnology applications in materials production, metals fabrication, and process industries. EPRI is putting major R&D efforts in these areas, and because of the potential large desirable national impact, we feel that these areas are also essential for DOE involvement.

There are numerous other areas of need which might interest the committee such as building-envelope research, lighting technologies, and opportunities of revolutionary proportions in semiconductor controls for motor drives, but time does not allow their discussion today. Suffice it to say that EPRI also conducts R&D programs in these areas, and there is a logical role for DOE as well, in many instances well beyond current levels. In particular, basic research support by the Federal Government is, critically important.

Heat Pump Technology

In 1983 electric heat pumps were used in approximately 30% of new single-family houses and slightly less in new multi-family dwellings. This represents a large increase over 10 years ago, driven by the efficiency, convenience, and reliability of the heat pump. Even broader application of heat pumps in the retrofit market as well as in the commercial and industrial sectors, is likely, and in the national interest, provided that aggressive R&D initiatives are pursued to further increase heat pump efficiency.

From a technical perspective, the full potential of the electric heat pump has not been realized. Current private-sector technology advancement efforts are inadequate for realization of that potential, as they are directed at nearer-term equipment and system improvement. The needed long-term research efforts are beyond the reach of the private sector because of their high-risk nature.

The current EPRI heat pump program for 1985 to 1989 is based on a research and development budget of $20.8 million. Our program includes limited proof-of-concept research, limited product development, and applications research. It emphasizes near-term R&D, on the premise that the U.S. DOE will sponsor the bulk of the needed exploratory research to continue to build the needed technology base for heat pump advancement. Given a strong DOE program, our program can serve as the next step for utilities to make basic advances in development and, working with manufacturing industries and users in the private sector, to accomplish the transfer of improved technology into commercial applications.

Specifically, we are cooperating with the U.S. DOE in exploratory research on new compression cycles, on advanced refrigerant mixtures, and in developing needed data and models on their thermo-physical behavior, all of which are needed for further improvement in the field. Our involvement in exploratory research is, however, necessarily quite limited, and we must rely on the U.S. DOE to provide, through basic research, the critical link between theoretical potential and product-oriented development programs in the private sector.

Industrial Electrotechnologies

The traditional energy-intensive industries--which importantly include steel, aluminum, metals fabrication, and chemicals--are under severe pressures from international competition. An acute need for productivity improvements has developed in order to maintain a continued viability, and in some cases, economic survival of these industries in today's world markets. New or drastically improved electric processes have significant promise to deliver these urgently needed productivity and efficiency improvements. Also, the acceptance of these processes in energy-intensive industries can significantly reduce the use of oil and, in the longer run, gas.

Economically troubled industries often are, however, unable to invest in the major R&D efforts needed to provide technical advantages. Moreover, for many small companies there is no cohesive organization which can adequately focus their limited resources on the advancement of technology and productivity.

Realizing the predicament of their customers and their own interest in the productive use of their product, the electric utilities asked EPRI to establish a R&D program for industrial electrotechnology development for 1985 to 1989 with a research budget of $20.3 million. The thrust of this program is two-fold. First, it supports the evaluation of electrotechnology applications and their prospective benefits to customers, utilities and the national economy. Second, selected R&D opportunities are supported by EPRI in focussed development projects and more broadly through our support of R&D application centers (RDACs).

Two specific examples of near-term beneficial electrotechnology applications being developed with EPRI support are a plasma cupola furnace for scrap melting and lasers for precision cutting.

In the plasma cupola pilot demonstration project, with the participation of the Westinghouse Corporation and the Modern Equipment Corporation a 2-1/2 ton-per-hour cupola with a 1.5-megawatt plasma torch will enable the foundry industry to dramatically increase productivity in metal scrap melting. Utilization of the high temperature characteristics (>10,000° F) of the electric plasma torch eliminates a presently required production step (briquetting) and reduces the quantity of expensive coke required for in the process. The plasma torch can also provide fast on/off control for the melting process, thus resulting in a better product. From this demonstration, it is estimated that the plasma-fired cupola will have a payback of approximately 2 years.

A second example of an electrotechnology application is in laser cutting. A laser cutting system, in conjunction with computer control software, has been installed in the Peerless Saw Company in a suburb of Columbus, Ohio. The manufacture of the circular saw blades was under severe competition by cheaper imports. The laser-cutting system enabled the shift in the process from punch-press operation into metal cutting by the focused laser beam in one-seventh of the time. The computer controlled system also allows the economic production of short orders. Thus, not only did Peerless regain their competitiveness, but they were able to expand their market from sawblades to all types of precision metal cutting business.

EPRI has also established Research and Development Application Centers (RDAC) as joint efforts with energy-intensive industries to enhance technology development and subsequent transfer to the users. Two centers now in operation are the Center for Metals Fabrication in Columbus, Ohio, and the Center for Metal Production in Pittsburgh, PA.

The U.S. DOE can greatly enhance the availability of innovative electrotechnology for the U.S. industry. Particular emphasis should be placed in fundamental research effort which will feed into EPRI and the R&D Application Centers. Basic research on materials, tribology, and electrochemical processes will strengthen the Federal partnership with the private sector. In addition, if we are to maintain competitive industries, development efforts are sorely needed. The areas of concern are:

1. heat pumps and process heating (i.e., induction and lasers for heat treatment, plasma applications to ore reduction and ceramic processing)

2. adjustable speed motor drives (for process efficiency improvement)

3. continued advancement in the electrolytic/electrochemical areas (to improve productivity).

Federal support is required, especially, in areas that can produce widespread benefits to the economy but which have market incentives that are too diffuse to attract adequate levels of R&D efforts by industry alone. We look forward to continuing our program planning coordination in these important areas with DOE and other governmental and private organizations. However, for this coordination to be effective, a strong exploratory R&D program at DOE's part must be maintained.

Mr. WALGREN. Thank you. That is a good statement.

Mr. Coda.

STATEMENT OF FRANK M. CODA, EXECUTIVE DIRECTOR-SECRETARY, AMERICAN SOCIETY OF HEATING, REFRIGERATING & AIR-CONDITIONING ENGINEERS, INC., ATLANTA, GA

Mr. CODA. Thank you, Mr. Chairman.

I am Frank Coda, executive director and secretary of the American Society of Heating, Refrigerating & Air-Conditioning Engineers, better known as ASHRAE. I am speaking today on behalf of our organization.

Mr. Chairman, ASHRAE thanks you for giving us the opportunity to comment on how the private sector, especially our organization, cooperates with the U.S. Department of Energy to develop research and to apply it.

In my remarks I will explain that, first, ASHRAE continues to stress the need for our Nation to conserve energy resources; second, how ASHRAE and DOE cooperation in the past has benefited the public; and, third, what type of research we believe is needed in the present and in the future.

ASHRAE is a not-for-profit organization of approximately 50,000 members worldwide. About 40,000 of those members reside in the United States. They are employed in consulting engineering or architectural firms, in contracting firms, by Government, by utilities, by equipment manufacturers, educational institutions and research organizations, and by the management of industrial facilities and commercial buildings. The objective of all ASHRAE activity is to benefit the public.

The need for continued energy conservation efforts and development of renewable energy sources is as important today as it was 10 years ago. As long as we depend upon natural resources which are available only in finite quantities, the long-term price of energy will increase, and we will experience energy shortages.

ASHRAE's energy policy pledges that the society will develop and distribute technical knowledge for design, application, installation, and operation of energy-efficient heating, ventilating, air conditioning and refrigeration, with due regard for human health, comfort and indoor air quality.

Our organization does this by accepting as its responsibility, first, the communication of new energy technologies to those who will put them into practice and, second, the motivation of industry to efficiently use energy resources.

ASHRAE also acts as a technical resource to Government in the formation of policies, laws, and regulations relating to the efficient use of energy resources in buildings.

ASHRAE and the Federal Government—first the Energy Research and Development Administration and later DOE—have successfully cooperated on many projects in the past. These projects can be divided into five categories: promulgation of standards, evaluation of Government research and manuals, cosponsorship of conferences, and direct research assistance.

Perhaps the most widely known examples of ASHRAE-DOE cooperation lie in the area of standards development. Standards benefit the public by outlining for industry and the profession accepted methods of product testing and design.

Because they are developed through a consensus procedure, ASHRAE standards represent broad-based agreement by concerned interests within the private sector. Government at the national, State, and local levels relies on ASHRAE standards as documents which have won acceptance by industry and consumers.

ASHRAE Standard 90, Energy Conservation in New Building Design, serves as the technical basis for energy codes in all 50 States. DOE helped to make possible accelerated development of standard 90, and DOE has made available research used in its revisions.

Other ASHRAE standards which have been developed with DOE support cover the thermal performance of solar collectors, standard 93; thermal storage devices, standard 94.2; ventilation for acceptable indoor air quality, standard 62; energy conservation in existing buildings, standard 100 series; and infrared sensing for heat loss, standard 101.

Another area of ASHRAE and DOE cooperation covers evaluation of Government programs and manuals. Several years ago, ASHRAE was called upon to train design professionals and building operators in the implications of the Federal Government's emergency building temperature restrictions, better known as the EBTR Program.

This effort raised a new level of awareness within the private sector about the energy conservation ethic, and EBTR certificates are still highly visible in many private and public facilities around the country.

More recently, ASHRAE developed, at the request of DOE, a manual to help State and local building officials interpret provisions of standard 90.

ASHRAE also jointly sponsors with DOE conferences which promote exchange of research and speed its application by building and equipment design professionals. One such ongoing series of conferences is concerned with the effect of the building envelope, such as glass walls, roofs, and construction techniques on energy use.

Another, the building energy research workshops, brings together representatives from building equipment manufacturers and national research organizations to identify areas of research overlap, gaps, and possible cooperative activities. These conferences and workshops provide a classic example of public and private sector cooperation.

The fourth area of ASHRAE-DOE cooperation involves direct research assistance. Within the past month, ASHRAE has been selected for DOE research projects of great importance to the building community.

One of the projects will attempt to answer the question of how much energy use should be targeted to various building types and occupancies. Both ASHRAE and DOE recognize that voluntary whole building energy targets which are comparable with the component targets included in standard 90 allow for greater design flexibility while achieving the same degree of energy efficiency.

By developing whole building energy targets in cooperation with the private sector, as called for in this current research project, DOE will be providing educational tools which will guide engineers, building design professionals and building owners in what energy utilization design targets are feasible, practical, and in the long-term interest of the public.

Results from the project may be used by the Federal Government to establish the performance standards required by the Energy Conservation Standards for New Building Act of 1976 for the design of Federal buildings, and the results will also be considered for inclusion in upcoming revisions of standard 90.

One of the important aspects of this project is that it involves the three principal private sector organizations responsible for building energy design: ASHRAE, the American Institute of Architects, and the Illuminating Engineering Society of North America.

The other recent DOE research project for which ASHRAE has been selected is a study of energy conservation in residences, an important basis for the development of the new ASHRAE standard 90.2, energy efficient design of new residential buildings.

This brings us to the present and to the future. ASHRAE highly values the research efforts, both in conservation and in alternative energy resource development, of DOE. One of the reasons why ASHRAE believes this cooperation has been effective is because of the open dialog which exists in the research planning between DOE and the private sector.

ASHRAE sees the following as areas in which both the private and public sectors should work together to develop and apply energy technology.

First, more information is needed on commercial building energy uses, both modeled and actual, in order to prepare an energy targets standard for commercial buildings which would be compatible with the component performance sections of standard 90.

Second, ASHRAE encourages cooperation on basic research relating to indoor air quality to be used to further upgrade standard 62, acceptable levels of indoor air quality. This research should take into consideration the needs to conserve energy and to provide for human health.

Third, continued fundamental research and development work in the field of solar energy should be sponsored. ASHRAE encourages development of a comprehensive solar design tools manual to assist engineers, architects, and other solar system designers.

We encourage work which will improve the operating performance of large active solar systems and which will promote active and passive solar cooling in the Sun Belt's hot and humid climates. We also support work to integrate active and passive solar systems with hybrid systems.

And, fourth, further research is needed in both heating and cooling systems installed in residences in order to study the effects of the interaction between the building, ventilation and infiltration, controls, and equipment on seasonal efficiencies. This is a continuation of the current ASHRAE, DOE and Gas Research Institute cooperative project 309, dynamic and seasonal performance of central forced warm air heating systems installed in residences.

ASHRAE-DOE cooperation has resulted in significant savings for the public good. ASHRAE supports continued emphasis on technology transfer and research utilization programs within both the energy conservation and the solar energy areas.

The value of federally sponsored research such as that contributed by DOE is lost if not effectively delivered in usable form to the private sector for development and utilization. ASHRAE believes that its past cooperation with DOE has effectively done this and hopes that it will continue.

That concludes my statement, Mr. Chairman.

Thank you.

[The prepared statement of Mr. Coda follows:]

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

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FRANK M. CODA
Executive Director-Secretary

March 1, 1985

Representative Don Fuqua, Chairman
Subcommittee on Energy Development and Applications
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

Thank you for inviting the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) to provide comment on the Department of Energy's conservation programs.

ASHRAE is a not-for-profit organization of individuals dedicated to advancing the arts and sciences of heating, refrigeration, air conditioning and ventilation and their related human factors for the benefit of the public.

There are 50,000 ASHRAE members worldwide. About 40,000 of them reside in the United States. They are employed in consulting engineering or architectural firms; in contracting firms; by government; by utilities; by equipment manufacturers; by educational institutions and research organizations; and by the management of industrial facilities and commercial buildings.

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The need for continued energy conservation efforts and development of renewable energy sources is as important today as it was ten years ago. As long as we depend upon natural resources which are available only in finite quantities, the long-term price of energy will increase, and we will experience energy shortages.

ASHRAE has long been concerned with heat transfer through the building envelope and the efficient operation of heating and air-conditioning systems and components. Studies to measure and verify energy consumption in existing buildings were funded by ASHRAE as far back as the 1920s. Studies on passive solar devices date back more than 40 years.

Today, ASHRAE has an energy policy which pledges to develop and distribute technical knowledge for design, application, installation and operation of energy efficient heating, ventilation, air conditioning and refrigeration with due regard for human health, comfort and indoor air quality.

The Society does this by accepting as its responsibility, first, the communication of new energy technologies to those who will put them into practice and, second, the motivation of industry to efficiently use energy resources. ASHRAE also acts as a technical resource to government in the formulation of policies, laws and regulations relating to the efficient use of energy resources in buildings.

When the price of energy began its rapid escalation in 1973, the need became apparent for an increased amount of technical information on energy use to supplement research efforts engaged in by ASHRAE and others in the private sector. Equally important was the need for accelerated application of energy technology.

The Federal government, through the Energy Research and Development Administration (ERDA) and later the Department of Energy (DOE), responded to these needs, and the public has been well served by it. Government and industry cooperation on energy research and development is one reason why from 1973 to 1983 total end-use energy demand declined at an average annual rate of 1.3 percent, after increasing at an average annual rate of nearly 3.8 percent during the decade before.

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For example, ASHRAE and DOE have worked together to promulgate energy conservation and solar energy standards. Standards benefit the public by outlining for industry and the profession accepted methods of product testing and design. Because they are developed through consensus procedures, ASHRAE standards represent broad-based agreement by concerned interests within the private sector. Government at the national, state and local levels views ASHRAE Standards as documents which have won acceptance by industry. ASHRAE views them as one of the most effective ways of promoting the application of new technology.

ASHRAE Standard 90 "Energy Conservation in New Building Design" serves as the technical basis for energy codes in all fifty states. DOE helped to make possible accelerated development of Standard 90, and DOE has made available research used in its revisions. Other ASHRAE standards which have been developed with DOE support cover the thermal performance of solar collectors (Standard 93), thermal storage devices (Standard 94.2), ventilation for acceptable indoor air quality (Standard 62), energy conservation in existing buildings (Standard 100 series), and infrared sensing for heat loss (Standard 101).

Another example of ASHRAE and DOE cooperation is in the evaluation of government programs and manuals.

Several years ago, ASHRAE was called upon to train design professionals and building operators in the implications of the Federal government's Emergency Building Temperature Restrictions (EBTR) program. This effort raised a new level of awareness within the private sector about the energy conservation ethic, and EBTR certificates are still highly visible in many private and public facilities around the country.

More recently, ASHRAE developed at the request of DOE a manual to help state and local building code officials interpret provisions of Standard 90.

ASHRAE also jointly sponsors with DOE conferences which promote exchange of research and speed its application by building and

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equipment design professionals. One such ongoing series of conferences is concerned with the effect of the building envelope, such as glass walls, roofs, and construction techniques, on energy use. Another, the Building Energy Research Workshops, brings together representatives from building equipment manufacturers and national research organizations to identify areas of research overlap, gaps and possible cooperative ventures. These conferences and workshops provide a classic example of public and private sector cooperation.

Direct research assistance is another important element in DOE-private sector cooperation. Just within the past month, ASHRAE has been selected for two DOE research projects of great importance to the building community.

One of these projects will attempt to answer the question of how much energy a building should use.

Both ASHRAE and DOE recognize that voluntary whole building energy targets which are comparable with the component targets included in Standard 90 allow for greater design flexibility while achieving the same degree of energy efficiency. By developing whole building energy targets in cooperation with the private sector, as called for in this current research project, DOE will be providing educational tools which will show engineers, building design professionals and building owners what energy utilization design targets are feasible, practical and in the long-term interest of the public.

Results from the project may be used by the Federal government to establish the performance standards required by the Energy Conservation Standards for New Building Act of 1976 for the design of Federal buildings, and the results will also be considered for inclusion in upcoming revisions of Standard 90.

One of the important aspects of this project is that it involves the three principal private sector organizations responsible for building energy design: ASHRAE, the American Institute of Architects and the Illuminating Engineering Society.

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The other recent DOE research project for which ASHRAE has been selected is a study of energy conservation in residences, an important basis for the development of the new ASHRAE Standard 90.2 "Energy Efficient Design of New Residential Buildings."

This brings us to the future.

Because of the past success of cooperative efforts, ASHRAE highly values the research efforts, both in conservation and in alternative energy resource development, of DOE. ASHRAE believes that to achieve maximum benefit for public benefit, the research agendas of government agencies and organizations in the private sector must be coordinated. That is why we welcome the opportunity to present our views on DOE research planning.

First, more information is needed on commercial building energy uses -- both modeled and actual -- in order to prepare an energy targets standard for commercial buildings which would be compatible with the component performance sections of Standard 90.

Second, ASHRAE encourages cooperation on basic research relating to indoor air quality to be used to further upgrade Standard 62 "Acceptable Levels of Indoor Air Quality." This research should take into consideration the needs to conserve energy and to provide for human health.

Third, continued fundamental research and development work in the field of solar energy should be sponsored. ASHRAE encourages development of a comprehensive solar design tools manual to assist engineers, architects and other solar system designers. We encourage work which will improve the operating performance of large active solar systems and which will promote active and passive solar cooling in the sunbelt's hot and humid climates. We also support work to integrate active and passive solar systems with hybrid systems.

And fourth, further research is needed into both heating and cooling systems installed in residences in order to study the effects of the interaction between the building, ventilation and infiltration, controls, and equipment on seasonal efficiencies. This is a continuation of the current ASHRAE,

... continued

DOE and Gas Research Institute cooperative project 309 "Dynamic and Seasonal Performance of Central Forced Warm Air Heating Systems Installed in Residences."

ASHRAE-DOE cooperation has resulted in significant energy savings for the public good.

ASHRAE supports continued emphasis on technology transfer and research utilization programs within both the energy conservation and the solar energy areas. The value of Federally sponsored research, such as that contributed by DOE, is lost if not effectively delivered in usable form to the private sector for development and utilization. ASHRAE believes that its past cooperation with DOE has effectively done this and hopes that it will continue.

Sincerely,

Frank M. Coda

FMC:wsc
enclosures

Mr. **Walgren**. Thank you, Mr. Coda.

We will turn to Mr. Vonier.

STATEMENT OF THOMAS VONIER, PRESIDENT, THOMAS VONIER, ASSOCIATES, INC., WASHINGTON, DC, AND MEMBER, ENERGY COMMITTEE, AMERICAN INSTITUTE OF ARCHITECT

Mr. **Vonier**. Thank you, Mr. Chairman and members of the subcommittee.

My name is Thomas Vonier. I am an architect in private practice in Washington, DC. I am here today representing the views of the American Institute of Architects.

I would like to begin by thanking this subcommittee for its past attention to the issues that are of concern to architects and for what I would characterize as a very sympathetic hearing of our views in the past on these subjects.

As I am sure you know, the AIA has a long standing policy in the area of energy conservation, and its support for programs in this area continues to be strong.

Our interest in these matters, I would say, is grounded in several principles which I would like to recite. With your permission, I am going to summarize and highlight the written testimony that we have prepared. I regret to have to inform you that it has already been summarized for us in the written version. There are a couple of pages at the back that apparently have been omitted in the printing. With your permission, we will furnish those tomorrow for the record.

First of all, I think that we are in the business of doing what the Government cannot do, or will not do, and as I hope you will see in my later remarks, we think there are some areas where it would be reasonable to expect that private industry would do more and that Government might do less.

Second, we have seen in prior years, and this year again, too much emphasis on components and pieces and parts of buildings and not enough on the interactions among those components. This is the area that has been called whole buildings research; it is now called building systems interaction research.

Architects are in the knowledge business, and that knowledge pertains to how to put parts of buildings together. Although we are interested in how those parts perform, each and of themselves, we are really interested in knowing more about how better to put them together and how to make the whole perform better.

We are in the business of deciding whether or not it is the gas heat pump, when that becomes available, or the electric heat pump that is most suitable for a given application, and we need the tools that allow us to make those judgments more easily.

Third, we certainly agree with our colleagues at ASHRAE that more emphasis has to be placed in the technology transfer area. Specifically, we think more emphasis has to be placed on using the established channels and associations for that purpose.

We recently participated in a very successful conference sponsored by ASHRAE with support from the Department of Energy on ways to improve the technology transfer process. I believe that report will soon be made available to DOE. We certainly hope they follow the recommendations that are contained therein.

Fourth in the list of general principles that guide the remarks I am going to make, we see a need to emphasize more commercial and nonresidential buildings and the contributions that architects and consulting engineers make in those areas of activity related to nonresidential buildings.

We understand and have policy in the area related to the need to balance the budget, to reduce the budget deficit. I also want to emphasize that our remarks are cognizant of that responsibility, and that is why we are supporting a freeze at the current fiscal year 1985 level overall for programs in the buildings and community systems area.

We want to emphasize further that we would not be pleased to see a further reduction in these programs, which are already 40 percent under levels where they were in fiscal year 1984. We think this is an important area and one that continues to deserve the kind of emphasis that has been given in the past.

We do have specific comments to make within line items, and I would like to go through those if I may, first in the area of commercial building systems interactions. As I have said earlier, this is the area in which comparisons, assessments of overall design strategies, and the combinations of building components become very important. We are recommending increased funding in this area to the level of $1.7 million, which even at that rate, I think, makes for slow progress in the years ahead.

I want to agree with my colleague from ASHRAE on the importance of the voluntary consensus standards and the new element that is being introduced to the existing Standard 90, which is very exciting to architects, this notion of voluntary energy performance targets, which we hope to cooperate closely with ASHRAE in developing, with DOE support. So the first area is this commercial building systems interactions or whole buildings.

Second, and not unrelated, is the area of performance monitoring. We see a need to have more emphasis in these programs on commercial buildings in hot/humid and hot/arid climates. It is our feeling that a good deal is known about performance in the cooler climates. We think there is a need for increased attention in the work of, particularly, the Pacific Northwest Laboratory and Brookhaven National Laboratory. There is a need for more examination of opportunities and performance particularly in hot/humid and hot/arid climates.

The third area is in design process research. These are activities at DOE that are, if we understand them, really aimed at knowing better how and at what points to influence the design process for buildings and with what kind of information. It is really part of the effective use of research results that come out of DOE programs. We see a need for increased funding in that area from the present recommendation of $100,000 up to $250,000.

Fourth, in the program line described as analysis and technology transfer, I would like to point out that this subcommittee last year rejected a proposal from the administration to establish energy-efficient centers, and wisely did so. We would urge you to do that again this year. It is our feeling that it is very unlikely that the centers would be used certainly by our members and that the funding proposed for that purpose could much better be used in other areas.

I want to come to the point I made initially and say that I think it is important that DOE continue to work through the established channels—the professional associations and building organizations—in the technology transfer area.

Further, I want to point out that we believe the research utilization program within DOE, which has been a separate item from the technology transfer program, ought to remain separate. It is being proposed for combination in this coming fiscal year. We think they ought to remain apart.

It has been my experience and, I believe, the experience of my colleagues in the AIA, that the programs within the research utilization area have been much more directly linked with the sort of day-to-day practical needs of architects than what we have seen in the technology transfer area in the past.

Fifth, in the area of indoor air quality, I must say I was pleased to hear EPRI place such emphasis on this area, because it is one of great concern to the American Institute of Architects. I am certain that proper guidance to design professionals in this area for commercial buildings is lacking. I suspect, but don't know for certain, that that is partly because some of the basic knowledge and evidence is simply not there to provide that guidance.

Whatever the case, it seems clear to the architectural profession that energy is somehow clearly linked with questions surrounding indoor air quality. It has been characterized as a culprit in some cases. It is certainly a matter of concern.

I think, in the indoor air quality area, there needs to be greater emphasis placed on commercial buildings, where the problems are simply coming to light in a way that had not been the case previously, and certainly more emphasis on monitoring commercial buildings. Most of the activity has been in the residential area in the past.

I also want to say that I think, ultimately, of most interest to architects, certainly, is the product that comes out of these efforts in the form of design guidance, things that we can use in making decisions and in recommending to our clients what the most sensible, safe, and effective measures are in the area of indoor air quality.

We believe that an increase in the budget item to $2.5 million in this area is warranted, and we think that cutting back in certain other areas—they are listed in our written remarks—would make that possible without an overall increase in the building and community systems budget.

Sixth and finally, in the area of solar buildings research—and I must note again that this is where the pages are missing in our written remarks—our interest is principally in the area of passive solar technology. I trust the members understand the distinction between passive and active systems. It is clear to us as architects that we can most readily influence the passive properties of buildings and that those are of most interest to us as we look at design alternatives.

We think there needs to be emphasis in DOE's program on the integration of building materials in full-scale buildings and in looking at how various materials perform in concert as contrasted with their performance alone and in scale model or mockup situations.

Second—a point I have made in other areas—we think that the application of passive solar technologies to commercial buildings needs greater emphasis. A good deal is known about the performance of these technologies in residential buildings. Less is known, obviously, for commercial and institutional buildings.

We think that data collection on the performance of passive solar commercial buildings ought to continue, ought to be emphasized; it ought to be done in a way that assures that results are put in a form that architects and engineers can understand and use in making recommendations to their clients about design measures.

I want to emphasize, as I think our colleagues in ASHRAE did, that it seems mistaken to us to eliminate the technology transfer activities in the solar area. It seems that that will be something that results in a further distancing of the profession from the research results that come out of DOE and its laboratories. We think it is important to have that link emphasized.

Also, we believe that emphasis on aperture systems—that is, windows and the various other openings in buildings that control the way in which solar energy enters buildings and affects them—ought to be emphasized. We think less emphasis on thermal storage materials would be warranted.

That concludes the oral remarks I wanted to make. I am pleased to answer any questions you may have.

Thank you.

[The prepared statement of Mr. Vonier follows:]

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STATEMENT OF
THOMAS VONIER, AIA
ON BEHALF OF
THE AMERICAN INSTITUTE OF ARCHITECTS
BEFORE THE
ENERGY AND APPLICATIONS SUBCOMMITTEE
OF THE
SCIENCE AND TECHNOLOGY COMMITTEE
OF THE
U.S. HOUSE OF REPRESENTATIVES

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ENERGY CONSERVATION AND SOLAR BUILDINGS RESEARCH PROGRAMS OF THE DEPARTMENT OF ENERGY

TESTIMONY BEFORE THE U.S. HOUSE SUBCOMMITTEE ON ENERGY AND APPLICATIONS

Mr. Chairman and members of the Subcommittee, my name is Thomas Vonier, AIA, President of Thomas Vonier, Associates, Inc., a Washington, D.C. architectural firm. I am pleased to present the views of the American Institute of Architects, on energy conservation and solar buildings research programs of the Department of Energy. The AIA is the professional association representing the nation's architects. I am an appointed member of the AIA's Energy Committee. I testified before this panel last year, and appreciate the opportunity to do so again.

The AIA is grateful to you Mr. Chairman for your interest in energy conservation and renewable resources, and commends you for holding this hearing today to encourage public discussion of these important issues.

My testimony today concentrates on several DOE programs under the Building and Community Systems programs, and under the Solar Buildings Research programs. My purpose is to indicate what research activities and accompanying funding levels will best aid us as architects in providing the most energy-efficient building designs.

The AIA's public policies strongly support conservation of fossil fuel. Energy savings increase our country's ability to maintain adequate energy supplies to preserve national security, power our industry and commerce, and provide comfort in our homes and workplaces. Reducing non-renewable energy use also enhances the quality of the environment. The AIA has backed up its public policies with direct investment of Institute funds to promote the benefits of reducing consumption of fossil fuels through improved building design. Our expenditures include about $2 million for an energy education program called "Energy in Architecture" which is a workshop series that increases the proficiency of our members' energy design skills.

We know energy conservation works. According to the Department of Energy's Annual Report to the Congress published in September 1984, "Since 1973, the amount of energy required to produce a constant dollar of gross national product has declined by more than 20 percent. Total domestic energy consumption in 1983 was actually lower than what it was in 1973."

Buildings are significant points of energy end use, and thus they can be principal contributors to energy savings. About 37 percent of the nation's energy use occurs through buildings, about forty percent of which is attributable to non-residential buildings. Our experience tells us that today's building designs are far more efficient than they were five years ago. According to DOE's own research, a building's energy use can be cut by as much as 40 percent when efforts are made to use the most efficient and cost-effective design measures available. This applies also to solar design. As the 1984 DOE report states, "a well-designed and well-integrated passive solar building is expected to use no more than 50 percent of the energy used by a similar conventional building."

The practice of architecture and energy conservation go hand in hand. As architects, it is our job to provide our clients with building designs that combine grace and form with function and performance, and in striking this balance to answer our clients demands for energy efficient structures--whether the clients come to us as homeowners, corporations, or governments. To provide the best service, we must know of the latest research results and how to apply them. Thus, it is clear that the energy conservation and solar buildings research programs under your Subcommittee's jurisdiction directly affect our ability to obtain the greatest energy savings through building design.

The recommendations I offer today comprise what the AIA believes will best produce the research results that architects will find most useful in their daily practices. My testimony is divided into two general sections--selected programs under the Buildings and Community Systems programs and selected programs of the Solar Buildings Energy Research program. Under the former, we direct the Subcommittee's attention to the following line items: commercial building systems interaction, performance monitoring, design process research, analysis and technology transfer, research utilization, and indoor air quality. For solar buildings research, we have concentrated on aperature materials, systems integration, and technology transfer.

In general, our recommendations for both research areas derive from several principles we consider fundamental to a successful energy conservation and solar research effort. We believe that DOE's research funds should support activities that the private sector cannot undertake on its own. Not only does this further the proper role of government, but it also increases the total research product available. In connection with this, we also favor the examination of the energy performance of building components in relation to one another rather than in isolation. We also believe in technology transfer activities that utilize the strengths of existing organizations and associations to pass research results to practitioners in the field. We favor new emphasis on research of commercial structures because of their complexity. And we believe that in developing its research programs in these areas, DOE should consult with practicing architects to benefit from their experience.

We have attached to this statement charts displaying the AIA's recommended funding levels for several programs for FY 1986, compared to FY 1985 appropriations and the Administration request for FY 1986.

In making these recommendations, the AIA is fully cognizant of the critical need to reduce the federal budget. We have endorsed a balanced budget through our own convention resolution and through a coalition of 32 national organizations primarily devoted to financial and construction concerns.

In furtherance of this national interest, we recommend that FY 1986 appropriations hold to the current year levels for building and community systems and solar energy research areas. We endorse these funding levels not because they represent what we believe is necessary. In fact, they do not even come close. Rather, we support these amounts as a balance between the high priority of energy conservation and solar buildings research and the equally high priority of progress toward a balanced budget. We hasten to add that we would strenously oppose any reduction below the FY 1985 level, which is already substantially less than for the previous fiscal year. Solar energy research, for example, dropped 40 percent from FV 1984 to FY 1985.

Within each program area we recommend increases in certain line items to reflect our sense of priorities. We would expect, therefore, reductions in other line items to compensate for the proposed increases, and we make some suggestions about where cuts might occur.

I would now like to offer specific funding recommendations for each of the program areas, and reasons for these recommendations.

BUILDING AND COMMUNITY SYSTEMS

Commercial Building Systems Interactions

The AIA has accorded the highest research priority to building systems interactions, or "whole buildings research". We were gratified when the Congess supported $2.45 million for this research area for both residential and commercial studies for FY 1985. For FY 1986, we support the Administration's funding level for residential buildings. We believe however, that $1.7 million should be provided for the commercial buildings aspect of whole buildings research for each of the next five years. Whole buildings research has won widespread recognition, including two awards from the distinguished Progressive Architecture magazine.

The priority that we place on whole buildings research stems from our belief that the greatest amount of energy savings can be achieved through an understanding of how a building's components perform in relation to one another, rather than in isolation. Buildings are much more than the sum of their parts. They function as dynamic, complex technical systems.

We believe that DOE's research program to date has placed too much emphasis on the study of individual building components, to the neglect of systems interactions. Last year, in fact, the Department proposed terminating the whole buildings research program altogether. Congress wisely rejected this idea. Only sophisticated analysis that compares one building design strategy to another, and takes into account the relationships among components, assessing the overall performance of the total system, can provide architects with the information needed for application to everyday practice.

A great deal of private research is already occuring on individual building components, much of it supported by private product and materials manufacturers. At the same time, because whole buildings research can be quite expensive, costing more than $700,000 for a single study, it lies beyond the reach of architectural or development firms. Such research also lies beyond the interests of private manufacturers, who prefer to spend their time and money on improving their own product lines. Meanwhile, whole buildings research is progressing very slowly. Of seventeen separate building types, only two--small office buildings and manufactured housing--have been the subjects of completed studies.

The whole buildings research program has also embarked on the examination of multi-family housing types and plans to look at retail facilities with its FY 1986 appropriation. We agree with this program direction, emphasizing however, that the pace is too slow. At the current rate of study, it will take fifteen to twenty years to complete the study of all significant building types.

The AIA believes that the federal government has no business undertaking what the private sector is able to do, and is apparently doing for itself. Rather it should direct its inquiry toward those research concerns that the private sector is unable or has no motivation to pursue.

As part of its whole buildings program, DOE plans to continue the joint AIA/ASHRAE work on the voluntary energy targets effort. This work will result in a vital, performance-based counterpart to the presently available component standards, and will use the voluntary consensus process to arrive at standards that are at once state-of the art and acceptable to private industry. These voluntary performance targets will provide architects and their clients with much needed objectives that are clear, attainable at reasonable cost, and without specification of the methods or materials to be used. The flexibility afforded by performance standards is essential to effective voluntary compliance.

PERFORMANCE MONITORING

Performance monitoring should be increased to $800,000 from the $400,000 allocated for FY 1985. This activity involves the monitoring of energy performance in actual buildings. DOE has established monitoring devices in seven restaurants and six office buildings, and should expand this project to include offices in hot/humid climates.

The data base on commercial buildings funded through the Battelle Pacific Northwest Laboratory should be continued in addition to the FY 1986 program envisioned by the Department. In addition, Brookhaven National Laboratory should be encouraged to continue and expand its programs in the area of monitoring metal buildings used for a variety of non-residential purposes. These types of buildings have accounted for more than half of new low-rise non-residential construction in recent years, and are a significant part of the existing building stock.

DESIGN PROCESS RESEARCH

The AIA urges an increase in the Department's program of design process research from $100,000 to $250,000 for FY 1986. The most significant energy savings can be achieved during the design phase of a building's development, before the components are fixed in place. It makes sense, therefore, to examine the building design process itself to determine the extent to which lessons can be derived and applied throughout the profession to make the process more energy-conscious. While the AIA applauds the Administration for proposing this important research project, we feel that the amount recommended is insufficient. In our view, DOE's proposed amount would allow enough to plan the project, but not enough to carry it out. Because the study will require teams of architects in the field working with architectural and engineering firms as they undertake their projects, observing them at their tasks and analyzing these observations, we believe that an additional $150,000 is necessary for FY 1986.

ANALYSIS AND TECHNOLOGY TRANSFER

In order for architects to take advantage of the design process to achieve energy savings in their projects, they must have information on energy saving options, while they are still determining building size, shape, orientation, and internal configuration. If it were directed toward transferring research results to practitioners in the field, DOE's technology transfer program could provide that information.

This year, the Administration requests $3.4 million for a combined technolgy transfer and research utilization program, in place of the programs that are currently separate. Included in the DOE proposal are funds to establish several energy efficient building centers and a fellowship program of eight persons at $50,000 each. Congress rejected a similar recommendation last year, and we urge the same action for this year's version. We also oppose the consolidation of the research utilization program with the technology transfer function.

DOE's plans would actually diminish the dissemination of technical research information to professionals in the field. We have serious doubts that the construction industry and design professions would use the centers and cannot see the justification for individually expensive fellowships when other activities offer much greater value. We believe that technology transfer funds should be used to work with existing organizations and associations to help them relate research data to their members, produce consumer information, educate the financial community about the benefits of energy conservation, and conduct seminars and briefings for state and local government agencies. We feel that these functions could be accomplished through $1.5 million in appropriations.

The research utilization program should remain distinct from technology transfer and receive $1 million in appropriations. It differs from technology transfer in that it provides ongoing informational services, not only informing architects and others of the availability of important research data, but also aiding them in applying the research. Products that they can use in their everyday practice involve written materials, trade journal articles, visual and auditory aids and training sessions and workshops. Research utilization also has provided the opportunity for design competitions for architectural students, and an institute for architectural and engineering schools, both worthwhile activities that should be continued.

INDOOR AIR QUALITY

As we search for ways to conserve energy in buildings we must be mindful of the need to protect the quality of indoor air. Research on indoor air quality should receive an appropriation of $2.5 million, $600,000 above the FY 1985 level. The nation has become increasingly aware of serious problems with the quality of air in homes and workplaces. Urban residents typically spend as much as 90 percent of each day indoors, making them dependent on properly functioning HVAC systems and on building designs that recognize the importance of air exchange. Excessively tight buildings seeking reductions in energy consumption, along with ill-advised interior alterations to original architectural features and imbalanced HVAC systems have led to increased levels of some pollutants above accepted air quality standards. In a number of instances, the poor quality of indoor air has caused serious health problems. The National Institutes of Occupational Safety and Health (NIOSH) have investigated over 200 commercial buildings where impure air has made occupants ill. Both biological and chemical culprits have been at work in mishaps traced to indoor air pollution, and scientists are growing increasingly aware that individual pollutants reacting to one another in the air may create effects on health that surpass those of individual pollutants acting separately.

The list of pollutants ranges from passive tobacco smoke, bacteria, and carbon monoxide to radon decay products, formaldehyde and asbestos fibers.

Indoor air quality research is at a nascent stage, and information is "fragmented, anecdotal, and often contradictory," according to John Spengler and Ken Sexton writing in the July, 1983 issue of Science magazine. They state that "a strategy should be developed to ensure a coordinated, well-managed investigation of indoor air pollution exposures and their health consequences." The call for such a strategy was recently echoed at an inter-disciplinary conference on indoor air quality held in Washington, D.C. on January 8-9, 1985, sponsored by the Consumer Federation of America and supported by the Environmental Protection Agency, the American Institute of Architects and other organizations.

The AIA believes that the DOE programs described in its budget request documents need to be part of a comprehensive strategy of research. In addition DOE should place greater emphasis on research on commercial structures, work with the private sector to establish effective monitoring procedures and to create a large data base for non-residential buildings, and develop mitigation techniques and equipment.

Beyond the $900,000 that we believe could be saved from the Administration's technology transfer program, we believe that other aspects of the DOE energy conservation research budget could be reduced to permit increases in activities of higher priority. For example, the AIA believes that the performance calculation and the building materials line items could both receive cutbacks. Under the former activity DOE proposes $800,000 to develop a new version of its DOE-2 simulation computer program, which is actually a research rather than a design tool. The new version of DOE-2 will apparently permit improved analysis of building mechanical systems.

Only a small portion of architects, builders, and engineers can use the current system because they must have computer capability, a skilled staff to take advantage of the program, and sufficient resources to pay the costs of what can be a very labor-intensive and expensive exercise. As practitioners, we do not believe that the program's relatively small use justifies the large expense.

SOLAR BUILDING RESEARCH

Solar energy techniques and applications can complement energy conservation activities. While the latter aims at reducing air infiltration or leakage or developing designs that result in the most efficient use, the former substitutes the limitless power of the sun for the limited resource of fossil fuels. Passive and active solar techniques can increase energy savings by 40 percent beyond what can be achieved through the application of energy conservation methods. As it supports active solar programs, the AIA has a particular interest in passive solar research activities because of their greater implications for building design. DOE's passive solar energy programs have advanced the art of passive solar design in several ways. Performance data on residential and non-residential buildings have been established. Residential design tools have been validated. Residential heating systems, preliminary residential cooling systems, and promising materials for storing heat and for glazing window systems have all been developed under the passive solar research program.

At the same time, there remains much work to be done essentially in non-residential buidlings. The AIA believes that three areas of passive solar research deserve the highest priority -- aperature materials, systems integration, and technology transfer.

Aperature Materials

The AIA supports $1.45 million for the aperature materials line item, which is $900,000 more than provided for FY 1985. We place high priority on this research aspect because it will produce the materials necessary to develop new types of glazing systems and coatings for windows. This area has more potential for a major breakthrough and will provide a greater contribution for solar application than thermal energy storage research, which the Administration plans to increase.

In conducting research into aperature materials and thermal storage, DOE should give added emphasis to assembling this research in actual building components. For example, glazing materials under development should be tested in windows. DOE should also explore daylighting techniques for atriums and cores of buildings.

Systems Integration

The AIA agrees with the Administration's over-all request for $4.1 million for systems integration, but we would apply slightly more to the non-residential buildings aspect of this research. Systems integration is the solar buildings version of the whole buildings research program which examines the performance of individual building components in relation to one another and to an entire building system.

DOE is moving in the appropriate direction under systems integration with a varied program. The Department plans to address multifamily and non-residential structures, types of buildings which DOE study has neglected to date. DOE is also moving toward applying first generation heating and lighting concepts to actual building design, and plans to consider retrofit applications.

Additionally, the program will package current research findings on daylighting into design guidelines, will move into daylighting systems for more complex buildings, and will explore ways to bring daylighting into the core of buildings, which will make building interiors use less energy for lighting. About 60 percent of energy use in office and retail facilities goes for lighting. Finally, the program will verify energy performance of laboratory prototypes and analytical models through performance monitoring, and it will work on passive solar cooling systems.

Technology Transfer

This function is closely related to the technology transfer program of the Building and Community Systems program. We have recommended $900,000 for this solar program. Unfortunately the Administration prefers not to fund it at all. The AIA thinks this is a mistake because it would greatly interfere with the dissemination of information about government sponsored research.

For FY 1986, the overall passive solar program should place greater emphasis on the following: integration of building materials and components in full scale building design; establishment of a common format for collecting cost and performance data on solar buildings that is acceptable to architects, engineers, lighting designers, and the financial community; and application of passive solar techniques to other buildings types such as retail and school facilities.

Mr. Chairman, this concludes my testimony. I am happy to answer any questions you may have.

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AIA Recommendations for
Selected Building and Community Systems Programs
for the Department of Energy

Program	FY 1985 Appropriation	Administration FY 1986 Recommendation	AIA FY 1986 Recommendation	Difference between AIA & Administration FY 1986 Recommendations
		(dollars in millions)		
Commercial Building Systems Interaction	1.327	.9	1.7	.8
Performance Monitoring	0	.4	.8	.4
Design Process Research	0	.1	.25	.15
Analysis and Technology Transfer	1.0	3.4	1.5	(1.9)
Research Utilization	.295	0	1.0	1.0
Indoor Air Quality	1.887	1.9	2.5	.6
Performance Calculation	1.225	.8	0	(.8)
Total	5.734	7.5	7.75	.25

AIA Recommendations for
Selected Solar Buildings Research Program
for the Department of Energy

Program	FY 1985 Appropriation	Administration FY 1986 Recommendation	AIA FY 1986 Recommendation	Difference between AIA & Administration FY 1986 Recommendations
		(dollars in millions)		
MATERIALS and COMPONENTS				
Aperature Materials	1.08	.55	1.45	.9
Thermal Storage and Transport	.96	1.45	.50	(.95)
SYSTEMS RESEARCH and DEVELOPMENT				
Non-Residential Building Systems	1.46	1.90	2.0	.1
Residential Building Systems	1.43	2.20	2.1	(.1)
TECHNOLOGY TRANSFER	.20	0	.9	.9
TOTAL	5.13	6.10	6.5	.85

DISCUSSION

Mr. **Walgren** (acting chairman). Thank you very much, Mr. Vonier.

Mr. Chairman, would you like to ask questions?

Mr. **Fuqua**. No, you go ahead.

Mr. **Walgren**. I just happened to catch, at the end of your statement—but not to hear well enough—the area where you were talking about where they were reducing the technology transfer efforts, and you felt that this was distancing the research effort. Which area was that?

Mr. **Vonier**. In the Solar Buildings research area. It is our understanding that no funding is proposed in the technology transfer activity for fiscal year 1986. The point is that that would serve, we think, to weaken the relationship between the research that is produced by DOE and the applications of that research in practice to buildings.

Mr. **Walgren**. Our budget breakouts do not often reveal that much, and the only thing that I can see in this budget breakdown is that the funds for what they group as analysis and technology transfer would be increased, but that would seem not to reach the level at which you are looking at for that program.

Mr. **Vonier**. I believe that the funding to which you refer pertains only to Building and Community Systems, which is a separate enterprise within DOE.

Mr. **Walgren**. All right.

Mr. **Vonier**. I am referring to the Solar Buildings activity.

Mr. **Walgren**. I see. Well, that is helpful.

Let me ask you, generally, when you see these kinds of programs that you have had experience with, do you feel that they are investments that should at least be maintained by the Congress, even given the prospect of budget deficits? By that I mean, do you feel that the programs that you see are reasonably cost-effective and are delivering increased value to the society as a whole, as opposed to expending resources? Can I ask that question, generally?

Mr. **Webb**. Yes, I would be glad to comment.

We certainly do. I know in the programs that we have with DOE, particularly if DOE and Congress continue to put the emphasis on programs where you have got a private sector involvement, so that in fact when the technology is developed, there is an industrial partner there that can carry it to the next phase, which is to either get the product into the marketplace or, in the case of the architectural work, get it into the design phase of the buildings.

If you look at what has happened in the past 5 years, I think, in the amount of energy improvements that have been made in the general economy of the United States, and you project forward, GRI's internal analyses indicate that a home built in the year 2025 will use 25 percent as much energy as the same home would today, based on all kinds of improvements, not only in products but the thermal shell of the home as well as a lot of new improvements in material.

If you look at the potential, I think this is probably one of the most cost-effective areas of investment in the DOE program. Again, I would emphasize, I think that Congress should continue to put emphasis on insisting that DOE's programs be directed toward activities that you can get actual cofunded dollars from the industrial sector so that you can go forward in some sort of a joint effort, and the research will actually be implemented.

Mr. WALGREN. Would others like to comment?

Mr. ZIMMERMAN. Yes. I, too, support what Mr. Webb has said. I would like to add a couple of more issues.

First of all, EPRI, funded by the electric utility industry through ratepayer moneys, has, you might say, developed a partnership in the transfer of the output from the DOE basic program areas.

I am a little bit concerned to lose the system that we have, what we have going for us in this area. I do not see the ratepayers being at this point in time willing to pick up directly through increased rates all of this Department of Energy work.

We feel that the work that you have is important. I think there are going to be some hard choices. There isn't any question about it. We have to make them daily. But I think it is the issue that we have something going for us here. I think we would lose a tremendous partnership by backing completely out.

There is no question that some areas might have to be slowed down. I would be very hesitant to drop major areas.

The second comment is really in this industrial productivity area. I don't think we as a nation can afford to put off that issue, period.

Thank you.

Mr. WALGREN. Is there another comment?

Mr. CODA. I assume that your question is really directed at the value of the research that is conducted by DOE. That is a very difficult question to answer because it ultimately evolves down into what is it worth to the public.

Mr. WALGREN. Yes.

Mr. CODA. Essentially, it boils down, too, to that research which the private sector may not engage in. A good example is the whole buildings energy budget research project that is now being undertaken. It is very important to obtain correct and accurate data to produce energy budgets or standards in that area.

Therefore, I guess the answer has to be that when you spend dollars on research, you have to evaluate what each project is worth by itself to determine whether or not it is right to spend the money.

Mr. WALGREN. Yes.

Mr. VONIER. I think a question in response to yours might be, compared with what? The American Institute of Architects, in my experience, comments on relatively few matters that come before Congress, and this one is one about which we feel very strongly.

We think there is room for improvement. We have made suggestions about where we think that room lies. I hope that my remarks and the written material emphasize the importance of getting the results of work that is sponsored by DOE into the hands of people who can use them. That, to us, is the acid test.

In response to the question about whether this is worthwhile, I think there is no question about it. It continues to be a matter of concern to architects because it is of concern to their clients. That, I think, is a reflection of the issue among a broader constituency than simply our own.

We are in it for the long term. We think that DOE is. Even though energy has receded from national consciousness, certainly, in comparison to where it was 10 years ago or even 5 years ago, it continues to be something that thoughtful people are concerned about and thoughtful people who make investments in buildings are concerned about. So I think it is essential.

Mr. WALGREN. Do you get any feeling, in looking at the budget, that in this retrenchment that we are going through, we are maintaining programs that have a higher Federal drive or pure Federal involvement and lessening programs that are, as I gather, ones that you would feel more comfortable with, those that have a substantial private sector close connection?

I may be saying that for not the right reason, but looking down this list of pluses and minuses within the Buildings and Community Systems budget strictly that is presented, the only winners seem to be relatively general programs that, my instinct is, are carried out more by the Federal establishment itself—analysis, Federal Energy Management Program, program direction. Those three lines are real winners, and all the line items—the appliance standards, technology in consumer products, community systems, the residential conservation, the building systems—are all net losers.

What I am wondering is, does that reflect, in your experience, a proper distribution of where you would plus and where you would minus?

Mr. VONIER. Well, I think that is a reflection of who we are and what we are interested in. When you speak of architects, I think it is not something one can compare to a product manufacturer or a seller of energy. We don't have the same kinds of resources that they do, and we are not really interested in many of the same kinds of things.

As I said before, we are really in the knowledge business and attempting to acquire the tools that allow us to be more effective as professionals.

So if we do indeed favor, as you say, those programs that appear to have a larger Federal contribution than those that do not, I think it is simply a reflection of our needs and our ability to participate.

Mr. WALGREN. Do other folks want to comment on that?

Mr. WEBB. If I could. I would just like to make one brief comment. Looking at the budget table that you are referring to, I think it probably reflects this administration's philosophy that they should get out of a lot of these areas based on their policy of industry picking it up.

Based on our own experience, we are like EPRI, our funds come through member company payments that are based on costs passed along to the ratepayers. The gas users of this Nation pay for the research we are conducting.

We have increased our budget, like I said. We are over 80 percent in near-term research activity in direct response to what the administration said 4 years ago. Now, then, what we see eroding, and our real concern, is the long-term basic research that feeds into our programs is also eroding.

We will not be able to increase the rates of the gas users so that we would pick up the total program. What has happened is, some of the long-term research is going to fall by the way. I don't think that is very good national policy, and I guess that is the reason that we are here today, really, testifying on our particular aspects of the program.

Mr. **Walgren**. Mr. Sensenbrenner.

Mr **Sensenbrenner**. No questions, Mr. Chairman.

Mr. **Walgren**. In just a few minutes, we will have to suspend and go vote, and we will be through with yourselves as a panel, but before that, several of you raised the indoor air quality area as one that deserves real attention and, I gather from that, more attention than it has had in immediate previous past budgets and perhaps those that are recommended now.

To the degree that we are falling short in giving the right attention to that, does that indicate that the Department has not been sensitive enough to your recommendations, to your directions, as private sector people in working with or at least taking the guide from people who have a practical contact with the need?

Mr. **Zimmerman**. I think there are several contributing factors. We are talking about energy conservation, which is the responsibility of this subcommittee. We are talking about public health, the responsibility, maybe, of some other part of the area.

I think the issue is, How do we bring the resources that are available in the responsible sectors of government to address this issue?

When the RCS program was implemented, the indoor air quality was flagged. If you go back and look at the records in this, it was flagged on the basis that somebody can figure out a solution for it, eventually. So the issue was raised. It was constructively raised.

But the problem that we see is that the utility industry is being asked to be the implementors of the weatherization effort, and there is a great anxiety among the implementors of whether or not the basic knowledge behind this philosophy some way is going to be taken care of. We are almost at a point of saying this has to be taken care of.

Thank you.

Mr. **Walgren**. Are there other frustrations with the degree to which DOE takes their guide from nongovernmental sources?

Mr. Coda?

Mr. **Coda**. I would like to address your question but not in terms of DOE but in terms of indoor air quality as far as the importance to ASHRAE is concerned, and just outline for you a little bit how important we feel it is in the light of activities we have going and planned.

Of course, we have standard 62, which is now being revised, which are the ventilation requirements for acceptable indoor air quality. We have tentatively planned for the spring of 1986 to hold an international conference on indoor air quality to emphasize the importance of the subject.

Recently, our board of directors has created an environmental health committee which, on its agenda, will include the following items: Determination of the relationships between health effect agents and HVAC equipment; address whether control of humidity reduces certain pollutants; evaluate the application of ventilation as a solution to indoor air pollution; review temporal dynamics of indoor air quality—for example, does weekend, seasonal, or night shutdown increase health hazards?—consider the development of various diagnostic evaluations that could help measure problems; and the evaluation of the efficiency of such techniques for improving indoor air quality as filtration, condensation, precipitation, absorption, and improved maintenance procedures.

So, as you can see, as far as ASHRAE is concerned, it is an area that is of increasing importance and one that we are certainly going to be active in, in the future.

Mr. **Webb**. Excuse me, Congressman. I would like to respond to your general question just real quickly.

I think probably our greatest frustration in working with DOE is we are able to work with the program people—I use the heat pump program as a specific example—and have really worked out what we think is a very reasonable approach, where they are doing specific tasks that are more long term related, and we are doing the near term. We are taking the prototype units to the field to field test them.

The policy, though, that drives a budget decision is such that usually, unless Congress restores the funding that is required to carry out like the second year or the third year of the program, then the DOE element just is not there to continue the program.

So it is a matter of somehow—and I don't really know that there is a solution to it in the current environment—of striking some sort of a balance so that there is consistency, so that if DOE says we want a 4-year, $20 million program, the private sector is going to put up $20 million and have some assurance that in fact the $20 million from the DOE is going to be there. That is really our greatest concern, and I am not sure there is an easy solution to that, sir.

Mr. **Walgren**. Yes. So one thing that we ought to flag is all programs where there is a substantial private sector contribution, and that deserves the benefit of the doubt for stability and continuity, because the private sector has gotten some money up.

Let me ask one other quick question on technology transfer and whether or not you feel that we ought to be trying to direct some new initiatives in that area. Is it functioning well enough in the contacts that you have had with that area, or should we as legislators be trying to direct certain funds and certain attention to it?

There will be proposals to set aside certain amounts of each of these areas, a budget for technology transfer purposes and that kind of thing. We need to know whether that is functioning at all at this point.

Mr. **Vonier**. Well, in our experience I would say it is very uneven, and the budget proposal in fiscal year 1986 seems to reflect to us some pretty misguided judgments in certain areas.

Mr. **Walgren**. A reduction in that effort, in particular?

Mr. **Vonier**. Well, I think in certain parts of it, yes. I mentioned the energy-efficient building centers, which seems like a misguided idea. There are also fellowships, I believe, that are mentioned.

Mr. **Walgren**. Any other thoughts on that?

Mr. **Zimmerman**. Yes. We are very appreciative of the support, both technical support and, very frankly, somewhat modest support that is being able to be given to the centers of excellence, the R&D applications centers. We have established two of them. One of them is the Center for Metals Fabrication in Columbus, OH; another is the Center for Metals Production at Pittsburgh.

In both of these activities, we have strong Department of Energy representation, and we have opened the doors to explore how we can merge our technology transfer activities. Basic knowledge without technology transfer is unemployed.

Mr. WALGREN. Are there other quick comments? I am going to be ruled out of a vote here if I don't leave. Yes?

Mr. CODA. I would just like to make one quick comment on technology transfer. When you talk about that subject, that is ASHRAE's business. We are specifically mandated to disseminate information on the arts and sciences of HVAC and refrigeration.

Therefore, the value of what we do is first based upon our own research program, which amounts to something close to $1 million annually and over $2 million on contracts in place. Therefore, again, our information that is turned out in terms of handbooks and other types of publications is based on that program, and also the research that comes in from outside our organizations, whether it be private sector or government, and that is a basic resources for the society.

Mr. WALGREN. Thank you very much on behalf of the Committee. I am going to excuse your panel at this time and go vote. The Subcommittee stands in recess.

[Recess.]

[Questions and answers for the record:]

GRI
gas research institute

1019 19th Street, N.W.
Suite 910
Washington, D.C. 20036
202/887-0426

DAVID O. WEBB
Senior Vice President,
Policy and Regulatory Affairs

May 15, 1985

The Honorable Don Fuqua, Chairman
Subcommittee on Energy Development & Applications
Committee on Science and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Mr. ~~Fuqua~~ Don:

I have attached Gas Research Institute's response to questions submitted after the Subcommittee's hearing of March 7, 1985, concerning DOE's conservation authorizations. If you need additional information, please let us know.

Thank you for extending the invitation to GRI to testify on those technologies which we believe should receive continued DOE support.

Sincerely,

David

David O. Webb

Attachment
cc: William Harvey

Gas Research Institute, 8600 West Bryn Mawr Avenue, Chicago, Illinois 60631 312/399-8100

1. GRI has identified its research activities in the thermally activated heat pump technology area. To what extent are you jointly funding projects in the thermally activated area with DOE?

   GRI's thermally activated heat pump program is fully coordinated with and complementary to that of DOE. DOE is a member of our Heat Pump Project Advisors Group, and GRI is represented on DOE's program review committee. GRI is funding thermally activated heat pump R&D at a level of $11 million in 1985 and $13.1 million in 1986.

2. Last year at its authorization hearings the Subcommittee heard that there had been recent breakthroughs in absorption cycle technology that would allow higher efficiencies than were previously thought possible. What is the progress to date?

   Significant progress has been made. In GRI's dual-cycle absorption heat pump research, testing on a full-scale laboratory breadboard unit has shown that performance targets of COP (heating) equal 1.8, and COP (cooling) equaling 0.94 can be achieved. R&D is continuing to develop a prototype unit in conjunction with the participating manufacturer. Continued success in this project could result in absorption technology being commercially available in the early 1990s.

3. GRI has noted that absorption technology is being investigated for introduction in the early 1990s. To what extent does the current level of funding by DOE allow for the requisite R&D to be completed in that time frame?

   The DOE work is of a more fundamental nature dealing with advanced absorption cycles and advanced fluid pairs. This work will potentially lead to second-generation absorption heat pumps with improved performance in the mid-1990s.

4. GRI's recommendation of $11 million in funding for DOE heat pump research is over twice the DOE request of $4.2 million for thermally activated heat pumps. Why is such an increase needed? To what extent will it accelerate the introduction of the individual technologies?

   The increase is needed to place more emphasis on long-term heat pump system development and analysis; supporting research in the areas of basic processes, materials, and generic component development; and for new concepts evaluation to determine those which should be moved into development. These activities would fruitfully be directed toward novel engine-driven systems and advanced chemical systems. Little or no work is being done in these technology areas, and, therefore, an estimate of how much their introduction could accelerate the program cannot be measured.

5. What will GRI's level of funding for thermally activated heat pumps be in FY 1986, if no additional funding is provided for DOE above the FY 1986 request of $4.2 million?

   GRI's planned funding for thermally activated heat pumps in 1986 is $13.1 million. We do not anticipate any increased funding in the GRI heat pump area if the DOE funding for FY 1986 is held at $4.2 million. GRI plans its budget approximately 18 months in advance of its fiscal year, and because it is approved annually by the Federal Energy Regulatory Commission, the budget figures cannot be altered because of changes in DOE's program. GRI's budget decisions in cooperative and coordinated programs are based on anticipated DOE participation. Without increased funding within the DOE budget, programs cannot be carried out as planned.

6. You have mentioned significant foreign R&D on heat pumps. What market penetration do you foresee in absorption, Stirling, and internal combustion technologies from foreign sources?

Significant development work on gas-fired, engine-driven residential-size heat pumps has been completed in Japan. This work was done in conjunction with MITI and now is being carried into commercialization by the Japanese gas companies and the equipment manufacturers. We anticipate that a modified version of the Japanese heat pump could appear in the U.S. market between 1988 and 1990. The potential market for heating systems for new and replacement applications is between 2.4 and 2.7 million units per year between 1985 and 2000. Of these heating systems, the portion that gas heat pumps will capture is still under study but anticipated to be significant.

Absorption chiller technology (larger than 100 refrigeration tons) applicable to commercial buildings is currently marketed in the U.S. by Japanese companies. The market has dropped from about 1,000 units per year in 1970, to about 150 units per year in 1983. This was primarily due to the low efficiency of single-effect absorption technology. The Japanese are employing double-effect technology, which is finding limited market acceptance. However, it is reasonable to expect that further improvement in absorption technology will be made by the Japanese. DOE's absorption work is properly addressing this area of improved absorption technology.

Stirling engine-driven heat pumps offer potential in second-generation prime mover heat pump technology. The most advanced work appears to be the Kinematic Stirling engine and is being conducted in the U.S. under GRI sponsorship. Japan, under the MITI Moonlight Program, is conducting a vigorous Stirling engine development effort. However, this technology is not expected to appear in the marketplace until the mid-1990s.

7. GRI testimony indicated the need for indoor air quality R&D. To what extent have you worked with DOE and EPA in developing a systematic plan to guide the research priorities in this area?

GRI has worked closely with DOE, EPA, CPSC, and Lawrence Berkeley, Oak Ridge, and Brookhaven National Laboratories. The relationship has been both formal and informal. For example, GRI has submitted formal comments to EPA on their research plan for health effects of short-term exposure to nitrogen dioxide. GRI is a cofunder, along with EPA, of a joint project in New York State, and along with EPRI and DOE, of a project at LBL to develop an indoor air quality database. An industry task group, chaired by GRI, has been established to work directly with CPSC to identify and resolve technical issues associated with its interest in indoor air quality.

The federal agencies are regularly asked to participate in workshops and conferences supported by GRI, such as those held at Harvard on personal monitoring instrumentation and exposure assessment. GRI has participated in several EPA-sponsored workshops including those held in June 1984 to develop research priorities.

In addition, there is frequent exchange of information at scientific meetings through report exchange and frequent telephone communication. EPA and National Laboratory personnel are members of GRI advisory boards.

To date, however, GRI has not been asksd to participate in the development of the indoor air quality research strategy requested by Congress and being prepared by the coordinating group on indoor air quality. GRI would welcome the opportunity to both review this strategy and to participate directly in the development of a strategy which involves not only the federal government but also local governments and the private sector.

8. DOE's FY 1986 Conservation Buildings and Community Systems budget request identifies $1.9 million for indoor air quality. What additional R&D activities are needed beyond those identified in the FY 1986 request?

GRI fully supports DOE generic, rather than source-specific, research in indoor air quality. There are three areas where DOE could profitably increase or accelerate its research. First is greater effort in the use of air infiltration and ventilation as a mechanism for indoor air pollution control. This would include not only whole housing pollutant reduction techniques but also additional research emphasis on spot ventiliation close to the pollutant source.

Second is in the area of indoor pollutant modeling. Mathematical models are being used with increasing frequency as a guide to policy and regulatory decision making. While DOE is proposing limited research in this area, we feel that it needs to be accelerated to include actual field verification, particularly of those models which involve multizonal transfer of pollutants and thermal demand.

Finally, GRI is currently supporting several indoor air quality surveys which should provide valuable information needed to design the proposed federally supported National Multipollutant Survey. At present, there is no federal support or participation in these surveys, and we believe that much could be gained by both DOE and GRI through active collaboration. Increased budget allocation would permit such participation.

EPRI
Electric Power
Research Institute

June 7, 1985

Honorable Don Fuqua
Chairman
Subcommittee on Energy Development
and Applications
Committee on Science and Technology
Suite 2321 Rayburn House Office Building
Washington, DC 20515
Attn: Ms. Tina Van Sickle

Dear Representative Fuqua:

Response to additional questions from the Members of the Subcommittee on issues covered at the March 7, 1985, hearing on 1986 DOE authorization request for the Conservation R&D Program are as follows:

1. Given the FY 1986 budget request for the Buildings and Community Systems program, is there an appropriate level and mix of R&D efforts focused toward exploratory research?

   The proposed level of funding will provide important contributions to the national needs in the building and community systems sector, and in the industrial sector. There are significant opportunities that need increased attention:

   o Moving closer to the course established earlier that the U.S. DOE take a leadership role in providing basic and exploratory research, support selected high risk proof-of-concept activities beyond the reach of the private sector and the transfer of this knowledge and products into the market.

   o Target a larger number of activities for early closer public-private sector coordination to optimize the probability of a good match between needs, R&D thrusts and user acceptance.

   o More clearly identify the broader vision that the efficient, cost effective use of energy, i.e., total productivity comprising energy, labor, capital and materials is the sustainable driver of all levels of activity in conservation, increased productivity, etc.

2. To what extent does DOE work with EPRI in planning R&D priorities in lighting and heat pump technology?

   EPRI has maintained close liaison with DOE heat pump and lighting programs both at the DOE program manager level and at the lead

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laboratory level. This has included plan reviews, selected joint seminars and supporting speaker assignments. In recognition of expertise in the laboratories EPRI has contracted several projects with them, i.e. LBL on indoor air quality and illumination. EPRI and National Bureau of Standards are jointly funding and managing work in heat pump fluids. We have started negotiations with ORNL for a year loan of one of their senior heat pump managers to assist in drafting a more comprehensive strategic electric pump plan.

The above steps have been important and helpful; however, there is further need to open our respective strategic planning activities earlier.

3. Your statement describes activities DOE could undertake with EPRI to conduct R&D at the Research and Development Application Centers in Columbus, Ohio, and Pittsburg, PA. To what extent has DOE participated to date?

To date, DOE has participated as a member of the Advisory Council for both the Center for Metals Fabrication (CMF) (Tom Gross - Office of Industrial Programs) and the Center for Metals Production (CMP), (Jim Fulton - Office of Industrial Programs). In this role, DOE is joining four utility representatives and four industry representatives in providing overall guidance to the Centers. In addition activities include:

- o Proposal submitted to DOE related to training at the Community College level in new technologies for metal fabrication.
- o Several steel related projects such as arc furnace dust and DC arc furnaces are under discussion.
- o Significant opportunity exists for DOE in technology transfer related areas and activities for both CMP and CMF.

DOE has been extremely supportive of efforts at these centers both in counseling and attendance of steering group meetings. We are continuing to urge a more supportive DOE role by sharing the funding of these collaboratory efforts.

4. EPRI testimony indicated the need for indoor air quality R&D. To what extent have you worked with DOE and EPA in developing a systematic plan to guide the research priorities in this area?

EPRI joined DOE and others in jointly sponsoring with your Committee, a Buildings Energy Workshop, the proceedings of which was referenced in my testimony. DOE presented their IAQ planning at two IAQ seminars held last year. We have been shaping our research plans building on the knowledge developed in the DOE and other efforts. EPRI is cosponsoring with DOE and GRI a "personal computer phone-in IAQ data base" at LBL to be available to all government agencies, researchers and utilities.

We appreciate the consideration your Subcommittee is giving to this area and will be pleased to work within the structure you and the other interested Federal entitites deem appropriate.

5. DOE's FY 1986 Conservation Buildings and Community Systems budget request identifies $1.9 million for indoor air quality. What additional R&D activities are needed beyond those identified in the FY 1986 request?

The earlier referenced workshop proceedings identified "health effects issues and contaminent control strategies" as critical issues if we are to continue tightening of homes with the accompanying reduction of ventilation as a means of saving energy. Specifically we recommend:

- More rigorous examination of indoor air pollutant sources, dispersion patterns, dillution and decay rates.
- A more complete understanding of the probability patterns of the concentration of these pollutants and their relative impact on health.
- Translation of natural siting phenomenon, i.e., random source knowledge, into generic guidelines.
- Encourage development of passive control strategies as preferred options to minimize current issues in taperability, reliability and energy efficiency of the active systems.
- Develop alternate scenarios for retrofiting structures with statistically high levels of pollutants.

Thank you for the opportunity to provide this information.

Very truly yours,

Orin F. Zimmerman

Orin F. Zimmerman
Technical Director
Energy Utilization

OFZ/lk

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle, NE • Atlanta, Georgia 30329 ☎ (404) 636-8400 • Tlx 705343 ASHRAE

FRANK M. CODA
Executive Director-Secretary

RECEIVED
MAY [illegible] 1985
COMMITTEE ON SCIENCE
AND TECHNOLOGY

May 14, 1985

The Honorable Don Fuqua
Chairman of the Committee
on Science and Technology
U.S House of Representatives
Rayburn House Office Building
Suite 2321
Washington, D.C. 20515

Dear Mr. Chairman:

Following are answers to questions contained in your letter of April 30, 1985. Please find enclosed a copy of the original questions for convenient reference to answers.

1. The Department of Energy has developed a research agenda for whole buildings energy targets. ASHRAE, AIA and IES are participants in the plan (Pacific Northwest Laboratory Contract #B-M7099-A-4). The provision for resources beyond the current six-month project is not known to us.

2. Not applicable (see #1).

3. A proposal entitled "Investigation of Active Solar Design Tools" has been made by ASHRAE to DOE to determine what additional solar design tools are available. Results will be available about nine months after approval of the proposal.

4. Several million dollars will probably be needed for indoor air quality research. ASHRAE is expected to spend approximately $250,000 - $350,000 per year in the next two years on IAQ research. ASHRAE has had discussions with DOE and EPA officials on IAQ research, but has not participated in developing a system plan.

5. From ASHRAE's point of view, DOE headquarters program managers have begun to work closely with the private sector in developing program priorities. In limited instances the same has been true of the National Laboratories. These trends need to continue and be expanded.

An International Organization

6. DOE has improved its use of existing resources for technology transfer. We believe that all research should be presented at technical society meetings for peer review. We also believe that the information needs to eventually reside in the appropriate industry accepted handbook in order to receive maximum utilization.

We are pleased to offer the above information. Should you or your staff have additional questions or need more information, please let us know.

Sincerely,

Frank M. Coda

Frank M. Coda

FMC/tes

cc: Robert O. McDonald
Donald R. Bahnfleth
J. Richard Wright
Tina Van Sickle

Hearing Questions - March 7, 1985

Mr. Frank Coda

1. In your prepared statement (p.4) you note the need for whole buildings energy targets. To what extent has the Department of Energy developed a research agenda that provides for specific goals, objectives, milestones and outyear resources needed to complete the required research?

2. How long would it take to prepare such a whole buildings research plan if one is not now available?

3. In your prepared statement you have noted the need for comprehensive solar design tools. Since a number of design tools have already been developed, what additional tools are needed?

4. ASHRAE has recommended future federal cooperation on basic research relating to indoor air quality. What level of funding is needed to carry out these activities? What level of funding is ASHRAE putting into indoor air quality in FY 1985 and FY 1986? To what extent have you worked with DOE and EPA in developing a systematic plan to guide the research priorities in this area?

5. The Committee has continually expressed the need for DOE Headquarters program managers, DOE National Laboratories, and SERI to work with industry in developing program priorities. In your opinion, to what extent has this been done in the Solar Buildings and Conservation Buildings Systems programs?

6. To what extent does the Department use existing resources in conducting technology transfer? Are alternative initiatives needed? In what areas?

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September 17, 1985

Ms. Tina Van Sickle
U.S. House Committee on Science
and Technology
U.S. House of Representatives
2321 Rayburn House Office Building
Washington, D.C. 20515

Dear Tina:

Enclosed please find the answers to the questions the Committee posed on technology transfer and other Department of Energy-related subjects. I appreciate your patience with the staff change and with our approval process. If you would like me to amplify anything, please get back to me.

Thanks for providing us the opportunity to respond.

Sincerely,

Albert C. Eisenberg
Director of Government Affairs

Enclosure

1. Q. The Committee has continually expressed the need for DOE Headquarters program managers, DOE National Laboratories, and SERI to work with industry in developing program priorities. To what extent has this been done in the Solar Buildings and Conservation Buildings Systems programs?

   A. In 1984, the Solar Buildings program funded an assessment of the building industry's needs for active and passive solar research. Approximately 17 building industry trade and professional associations were asked to supply information about what types of research would be helpful to solving problems that members face when they design and construct energy efficient buildings. The conservation programs have not undertaken a similar assessment, but appear to rely more heavily on input from the national laboratories and the Department's own internal priroities.

2. Q. With large amounts of R&D dollars expended by DOE, what emphasis and funding is provided for technology transfer in the FY 1986 Solar Buildings and the Conservation Buildings Sytems programs?

   A. There is no money explicitly for technology transfer for the Solar Buildings program. The Technology transfer funds within Solar programs will not fund buildings-related technology transfer activities, but will fund the Solar hotline and other nonbuildings activities.

3. Q. To what extent does the Department use existing resources in conducting technology transfer? Are alternative initiatives needed? In what areas?

   A. A building industry roundtable on technology transfer was held earlier this year. Included were DOE and major representatives of the building and design fields. Recommendations were offered to improve DOE's technology transfer activities, yet many of these recommendations have not been implemented. DOE needs to work much more closely with the existing industry structure for transferring technology to the field, and not rely on the national laboratories to establish technology transfer priorities and mechanisms.

4. Q. AIA testimony indicated the need for air quality R&D. To what extent have you worked with DOE and EPA in developing a systematic plan to guide the research priorities in this area?

   A. Both the Department of Energy and the Environmental Protection Agency have proceeded without consulting the AIA.

5. Q. DOE's FY 1986 Conservation Buildings and Community Systems budget request identifies $1.9 million for indoor air quality. What additional R&D activities are needed beyond those identified in the FY 1986 request?

A. While 16 organizations including DOE are signatories to a coordinating strategy for residential buildings, as indicated in our testimony the DOE program on indoor air quality provided in the FY 1986 budget request needs to be incorporated into a comprehensive research strategy particularly directed toward commercial buildings. We also believe that additional sums needed to be invested in the examination of commercial structures, creation of a large data base for non-residential buildings, development of mitigation techniques and equipment, and establishment of effective monitoring procedures.

6. Q. For FY 1986, the Department of Energy has proposed $3.4 million for anlaysis and technology transfer activities in the Buildings and Community Systems program. In your opinion, does this provide sufficient resources to carry out technology transfer efforts?

A. The Department of Energy has requested $3.4 million for FY 1986 for technology transfer activities. However, the AIA does not agree with the priorities established by the Department. We don't believe that either the Fellowship program or the Energy Efficient Buildings Center are cost-effective technology transfer mechanisms. Rather it is more appropriate that DOE work directly with building industry associations and traditional transfer mechanisms (journals, newsletters, computer programs) rather than starting up new and unproven ones. As a result, the AIA has felt that this area could accomplish its job for $2.5 million, and the savings shifted to other research functions, such as whole buildings research.

7. Q. Is the Department of Energy using existing resources effectively to leverage federal R&D funding? To what extent does AIA work with DOE in developing an integrated approach for technology transfer?

A. The Department has not sought the AIA's views on its technology transfer program as part of its legislative development process. As noted in the answer to question 6 above, the AIA has objected strenuously to certain aspects of its technology transfer recommendations. To the extent that DOE uses existing resources effectively for technology transfer activities, it does so in the context of Congressional direction.

Mr. **Fuqua** [resuming as Chair]. The subcommittee will resume.

Our second panel will be Mr. Jean-Louis Poirier, manager of Hagler Bailly & Co. of Washington; Dr. Edward Kelleher, vice president for technology, Champion International Corp.; and Dr. John Elliott, AISI Distinguished Professor of Metallurgy at MIT.

Mr. Ritter, one of panelists looks, from his hometown, as if he is probably a constituent of yours.

Mr. **Ritter**. I would like to accept Mr. Leonard as my constituent, yes, and acknowledge that.

Mr. **Fuqua**. Dr. Leonard is vice president for technology of Bethlehem Steel.

PANEL 2: INDUSTRIAL CONSERVATION

We are pleased to have you gentlemen. Mr. Poirier, you may begin.

STATEMENT OF JEAN-LOUIS POIRIER, MANAGER, HAGLER, BAILLY & CO., WASHINGTON, DC

Mr. **Poirier**. Thank you, Mr. Chairman and members of the subcommittee.

I am Jean-Louis Poirier, a manager at Hagler, Bailly & Co., and I am testifying on behalf of Henri-Claude Bailly, who is the president of Hagler, Bailly & Co., who could not be here today due to a last-minute change in the schedule of this testimony.

Hagler, Bailly & Co. is a management and technical consulting firm specializing in energy markets and technologies.

Mr. Chairman, I would like to submit for the record a copy of the written testimony prepared by Mr. Bailly.

Mr. **Fuqua**. Yes, we will make that part of the record.

Mr. **Poirier**. Thank you, Mr. Chairman, and I will now summarize Mr. Bailly's testimony.

Mr. Bailly and I recently completed a study of government-sponsored research, development and demonstration, RD&D, activities in industrial energy conservation in four European countries: the Federal Republic of Germany, France, Sweden, and the United Kingdom.

Our study was an update of a study our firm conducted in 1981, which was the basis of Mr. Bailly's testimony before your subcommittee on March 11, 1982. Today I will discuss the changes that have taken place since 1981.

In our recent study, we compared European and U.S. Government-sponsored RD&D expenditures in industrial energy conservation on the basis of gross national product. The situation has changed little since 1981. Sweden's expenditures remain over 30 times higher; the United Kingdom's, 10 times higher; France's, 8 times higher; and West Germany's, 1½ times higher than U.S. expenditures.

One prime motivation for European RD&D support is the rising price of imported oil in Europe. Although the price of oil traded in dollars has fallen since 1981, deteriorating exchange rates between the dollar and European currencies have forced European countries to pay substantially more for their oil, in some cases, 50 percent more in 1984 compared to 1981.

Higher oil prices prompted European governments to search for high-quality RD&D investment. These governments have shifted their emphasis from just saving energy to actively promoting the efficient and cost-effective use of energy. Their goal is not only to make marginal improvements but to substantially redesign industrial processes.

Furthermore, those four countries recognize that high-quality RD&D can increase industrial productivity. The criteria they use to select RD&D projects more and more reflect industrial productivity.

All four countries have also found that to promote new industrial energy conservation technologies can do more than just reduce oil imports; it can also increase exports by improving the competitiveness of exporting industries such as iron and steel, a major recipient of government aid in all four countries, cement and glass in West Germany, pulp and paper in Sweden, and chemicals and food in France.

In conducting their RD&D activities, France, West Germany and Sweden have pursued several aims in the last 3 years. They aim at diversifying RD&D activities outside major industries such as iron and steel, pulp and paper, stone, clay and glass or chemicals. They aim more and more at generic RD&D programs which are applicable to several industries at the same time; for example, in combustion, separation techniques, and heat exchangers. They put more emphasis on integrated processes than on the development of components.

Finally, they favor the development in private plants of semicommercial installation for testing purposes so that the same installation can be used for several R&D projects.

France, the United Kingdom, and Sweden have devised new tools to successfully transfer new energy conservation technologies into the marketplace. Sweden and France, for example, award special grants to replicate first-of-a-kind projects in various industries and regions. Sweden, France, and West Germany provide financial aid specifically targeted at those very technologies that are developed through government-sponsored RD&D activities.

In addition, the French and United Kingdom Governments are placing greater emphasis on strengthening their energy conservation industry and helping it to develop and sell its products both at home and abroad. Such efforts are considered part of a diffusion step in France and part of a deployment step in the United Kingdom. In other words, the RD&D process has been broadened to an RDD&D process.

To strengthen their R&D process, France and the United Kingdom created special energy organizations. They have also centralized their RD&D activities to achieve better coordination with regions, the private sector, and research organizations.

The creation of the French Energy Conservation Agency—also called AFME—was a mark of the ambition of the 1982 French energy program. AFME had a substantial staff in 23 regional delegations to reach all parts of the country and doubled government-sponsored R&D activity. AFME's status as a superagency helped project a powerful image in favor of energy conservation in France.

In the United Kingdom, with increased focus on deployment activities, a new energy efficiency office, the EEO, was formed within the United Kingdom Department of Energy. The EEO embraced all government departments to spearhead a new coordinated drive and to increase the visibility of energy conservation.

With strong government RD&D support at home, European equipment suppliers can focus on their exports. The United States continues to be the plum, with an estimated market of $80 billion in energy-efficient industrial products over the next 10 years. European firms are concentrating more and more on exporting to the United States energy-efficient electric motors, specialized heat exchangers, fluidized bed boilers, cogeneration prime movers, and process controls.

A recent study conducted by Hagler, Bailly identifies several types of U.S.-made equipment facing strong competition from foreign equipment. Prime targets seem to be foundry machinery, heat treatment equipment, electric motors, small cogeneration systems, filtration equipment, mechanical power transmission equipment, and industrial food, beverage, and tobacco-processing machinery.

If foreign companies can beat U.S. companies on their own turf, they can also beat them in the developing countries. We estimate the demand for energy-efficient industrial equipment in developing countries over the next 10 years at $80 billion, equal to the size of the U.S. market.

When Mr. Bailly testified before your Subcommittee in 1982, the Administration was proposing to eliminate Government support for industrial energy conservation R&D. At that time, Mr. Bailly said it would be suicidal to eliminate the only Government-funded civilian R&D program in industrial process efficiency, in light of our major trading partners' RD&D policies and programs.

Mr. Bailly and I are pleased that the Congress did not go along with the Administration's first request. Although the budget of the Office of Industrial Programs is modest, particularly when compared with the efforts of the United Kingdom or Sweden, it will allow the United States to pursue important development efforts in such areas as separation systems, materials processing, grinding, sensor and control systems, and industrial waste utilization.

As a result, OIP's RD&D activities will include many of the industrial energy conservation technologies that our trading partners are pursuing. I would like, however, to make a few recommendations for strengthening OIP's program management.

First, given the budget vagaries of the past 2 or 3 years, we need a clear signal that OIP is here to stay and that a new climate of trust between OIP and the private sector can be fostered. Multiyear funding—not necessarily higher funding—could go a long way in strengthening OIP's role.

Second, OIP can help to increase industrial productivity if it is allowed to broaden its focus to include not only energy savings but also savings in capital equipment, labor, and materials.

Third, OIP should seek a greater involvement of the private sector in its activities; for example, in the evaluation of new projects.

There are probably ways of avoiding potential conflicts of interest as the United Kingdom seems to have done.

Fourth, OIP should step up its information transfer activities and continue to monitor technology developments abroad.

Mr. Chairman and Members of the Subcommittee, thank you very much for your time and attention. I will be glad to answer any questions you may have.

[The prepared statement of Mr. Bailly follows:]

STATEMENT OF

HENRI-CLAUDE BAILLY
PRESIDENT
HAGLER, BAILLY & COMPANY

FY 1986 AUTHORIZATION FOR THE DEPARTMENT OF ENERGY'S CONSERVATION RESEARCH AND DEVELOPMENT PROGRAMS

MARCH 7, 1985

* * * * *

Mr. Chairman, Members of the Subcommittee:

I am Henri-Claude Bailly, president of Hagler, Bailly & Company, a management and technical consulting firm specializing in energy markets and technologies. Our firm is a division of RCG International, one of the largest consulting organizations in the world, with permanent offices in over 10 countries.

I appreciate the opportunity to testify on the results of a recent study* conducted by Hagler, Bailly & Company on government-sponsored research, development, and demonstration (RD&D) activities in industrial energy conservation in four industrialized nations: the Federal Republic of Germany, France, Sweden, and the United Kingdom.

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*Study conducted by Mr. Henri-Claude Bailly and Mr. Jean-Louis Poirier of Hagler, Bailly & Company for the Office of Industrial Programs of the U.S. Department of Energy, Government-Sponsored Industrial Energy Conservation Research, Development, and Demonstration: A review of programs in the Federal Republic of Germany, France, Sweden, and the United Kingdom. The study, completed in January 1985, was performed under contracts DE-AC01-81CS40405 and DE-AC01-84CE40646.

A review of other countries' programs in industrial energy conservation RD&D can provide a basis for comparing, evaluating, and improving the cost-effectiveness and competitiveness of U.S. activities in that domain.

The recent study is an update of a study* that Hagler, Bailly & Company conducted in 1981 and that was the subject of my previous testimony before your Subcommittee on March 11, 1982. In this second testimony, I will therefore discuss the changes that have taken place since 1981 in industrial energy conservation RD&D in the four European countries that we reviewed.

During the course of our recent work, which was carried out between August 1984 and January 1985, we reviewed numerous published and unpublished documents and interviewed representatives of many organizations -- public, quasi-public, and private -- involved in industrial energy conservation RD&D in each of the four countries. In reporting our results, we address only those program activities that fall directly within the purview of the Office of Industrial Programs (OIP) of the U.S. Department of Energy. Consequently, we excluded in some cases (e.g., Germany, Sweden, France) RD&D activities that would be carried out by U.S. government divisions other than OIP (e.g., coal gasification, peat pelletizing, nuclear heat exchangers). We also had to normalize differences in fiscal years (i.e., the Swedish fiscal year starts in July, the British in April, and the French and German in January) so that we could use a common calendar year basis to compare RD&D budgets among countries. In total, the governments of the Federal Republic of Germany (FRG), France, Sweden, and the United Kingdom spent approximately $69 million on industrial energy conservation RD&D and related activities in calendar year 1984. U.S. government expenditures for 1984 are estimated at $33 million.

We found numerous similarities between the industrial energy conservation strategies, organizations, activities, and budgets of the countries. In terms of strategy and organization, strong similarities exist between France and the United Kingdom. In terms of activities, France and Sweden have most in common.

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*Government-Sponsored Industrial Energy Conservation Research, Development, and Demonstration, A review of programs in the Federal Republic of Germany, France, Japan, Sweden, and the United Kingdom, November 1981. Prepared by Hagler, Bailly & Company for Battelle Pacific Northwest Laboratories, under Contract Number B-B4154-A-H.

Most importantly, we found that all four countries have actively supported industrial energy conservation since 1981, despite budgetary constraints. One key motivation has been the continued rise (in domestic currency) in the price of imported oil in Europe over the last 4 years; the drop in the price of oil traded in dollars was offset by deteriorating exchange rates between the dollar and the European currencies. As shown in Exhibit 1, oil prices between the beginning of 1981 and the end of 1984 have increased by 64 percent in Sweden; 61 percent in France; 51 percent in the United Kingdom; and 17 percent in the FRG. In contrast, the price of imported oil to the United States dropped by 17 percent during that same period.

We also found that the governments of all four countries support industrial energy conservation on two fronts: they stimulate the demand for industrial energy conservation technologies through financial aid, and promote the supply of such technologies through RD&D activities.

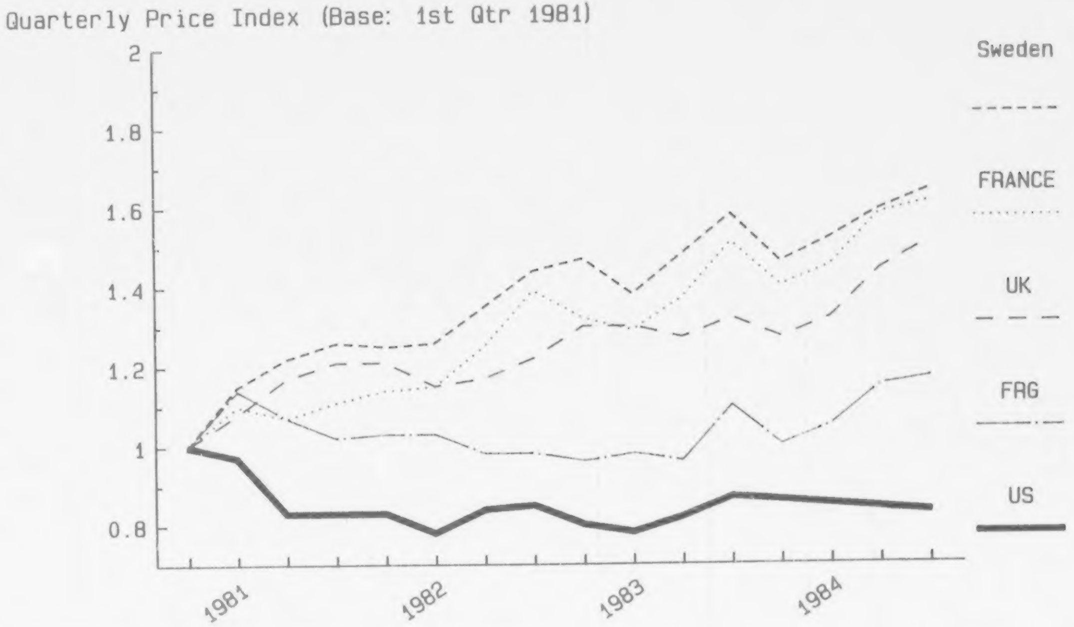
Since 1981, these government have provided significant financial aid in the form of investment grants and subsidies from special multi-year funds. In total, all four European countries provided the equivalent of over $270 million in financial assistance on average per year between 1981 and 1984 for an average combined GNP of $1.7 trillion, or slightly more than one-half the GNP of the United States.

On the basis of our analysis and our interviews with officials of all four governments, we have concluded that three major trends in RD&D activities have emerged:

- A search for "high-quality" RD&D
- An increase in the link between industrial energy conservation RD&D and industrial productivity
- An emphasis on technology transfer and on support for the development of an energy conservation industry.

Exhibit 1

Comparative Oil Prices For Industrial Use in Europe and the United States



Source: Int'l Energy Prices 1979-1983, EIA;
DOE/EIA-0424; Hagler, Bailly & Company.

Note: Heavy fuel oil prices - incl. taxes.

In their search for "high-quality" RD&D investments, the four countries have shifted the emphasis from "saving" energy to promoting the efficient, cost-effective use of energy. The search for "high-quality" investments has been a primary motivation in all four countries, which implies that RD&D programs are more selective and result not only in marginal improvements, but involve substantial redesign or changes in process configuration.

The search for "high-quality" RD&D was fueled by a growing recognition in all four countries that industrial energy conservation can increase industrial productivity. The proportion of government-supported projects involving automatization and control technology has considerably grown in each country since 1981, and the criteria used to select RD&D projects increasingly reflect industrial productivity.

The link between industrial energy conservation and industrial productivity caused all four countries to devise creative ways of refining -- if not optimizing -- the RD&D process. In particular, they have sought to improve the coordination between financial aid mechanisms (on the "demand" side) and RD&D aid (on the "supply" side). For example, Sweden, France, and the FRG have on several occasions passed regulations to provide more equipment-specific financial aid for technologies developed through government-sponsored RD&D activities.

All four countries are also increasingly aware that the promotion of new industrial energy conservation technologies can do more than just reduce oil imports. It can also increase exports by improving the competitiveness of exporting industries such as iron and steel (in all four countries), cement and glass (FRG), pulp and paper (Sweden), and chemicals and food (France).

As they have found that industrial energy conservation can de facto be an element of sound industrial policy, France, the United Kingdom, and Sweden have stepped up their activities and devised new tools to ensure the successful transfer of new energy conservation technologies to the marketplace. One example is the tendency in Sweden and France to promote the replication of demonstration projects through special grants awarded to "first-of-a-kind" projects in a given industry or a region. Improved technology transfer has also been achieved through increased private-sector participation and increased emphasis on regional coordination.

In addition, the French and U.K. governments, in particular, are placing greater emphasis on strengthening their energy conservation industry and helping it to develop and sell its products both at home and abroad. Such efforts are considered part of a "diffusion" step in France and part of a "deployment" step in the United Kingdom. In both cases, the RD&D process has been broadened to a RDD&D process.

We characterized differences in RD&D strategies among the four countries by examining the mix of RD&D activities and diffusion/deployment efforts conducted by each country. We also analyzed the evolution of each country's strategy by comparing the country's activity mix in 1981 and in 1984 (see Exhibits 2 and 3).

Our findings indicate that France, Sweden, and the United Kingdom have broadened the spectrum of their industrial energy conservation activities; they have increased their involvement in programs dealing with accelerated commercialization, information transfer, and energy advisory services, and have added programs on aid to export and aid to manufacturers and promotion abroad.

France, the country that has opted for the widest and most exhaustive coverage of the RD&D process, has continuously offered the greatest array of incentives since 1981. By design, the French government addresses each level of product development and follows up closely on the results of its activities. It also strongly emphasizes promotion and publicity at home and abroad.

The United Kingdom has, since 1981, moved aggressively toward deployment activities. At the same time, it has kept its emphasis on demonstrations and continues to support limited R&D.

Sweden has maintained a strong RD&D program since 1981, and although its current involvement in deployment activities is minimal, it intends to become more involved with such activities. Sweden's strategy and approach to industrial energy conservation RD&D have not changed much in the last 3 years.

The FRG has narrowed its RD&D process since 1981 to focus on medium-term R&D activities, dropping both long-term research and short-term commercialization efforts.

Exhibit 2

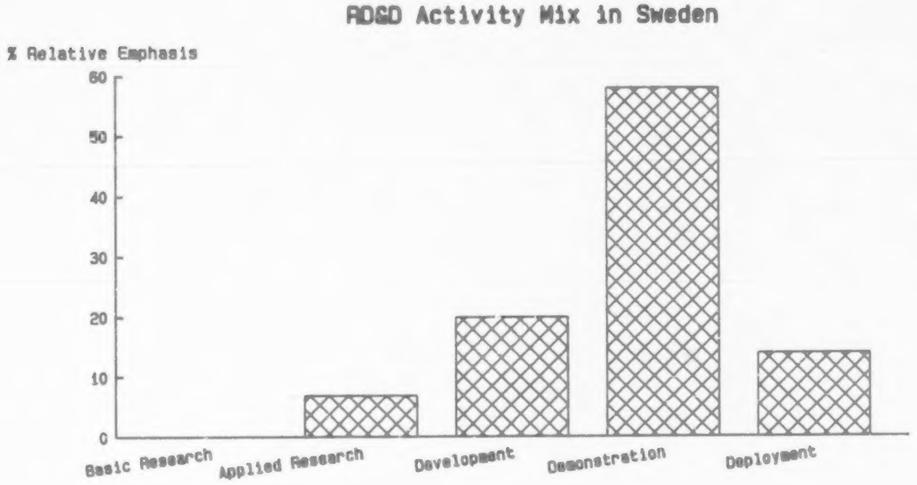
Changes in RD&D Activity Spectrum Between
1981 and 1984 in Four European Countries

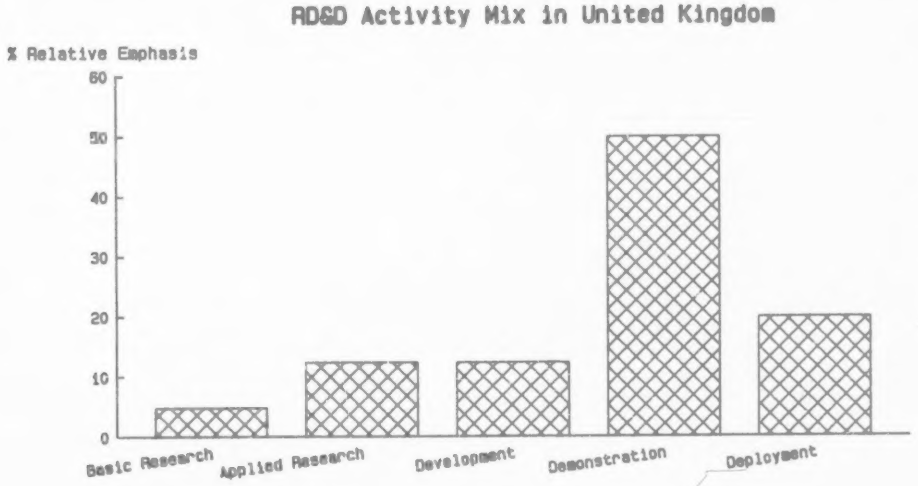
		RD&D activity spectrum						
			Applied research			Demonstration		
Country	Year	Basic research	Mid-term	Short-term	Development	First-of-a-kind	Replication	Diffusion/deployment
Federal Republic of Germany	1981	X	X	X	X	X		
	1984		●	●	●	●		
France	1981		X	X	X	X		
	1984	●	●	●	●	●	●	●
Sweden	1981			X	X	X	X	
	1984			●	●	●	●	
United Kingdom	1981			X	X	X	X	
	1984			●	●	●	●	●

SOURCE: Hagler, Bailly & Company.

Exhibit 3

RD&D ACTIVITY IN FOUR EUROPEAN COUNTRIES

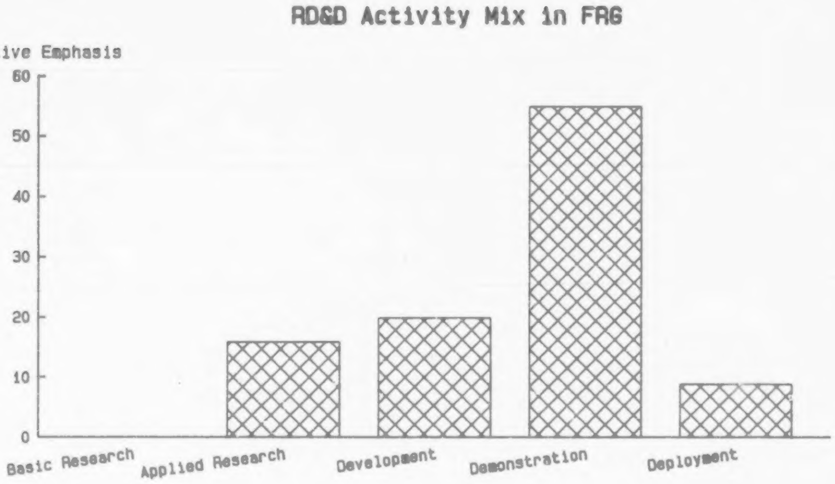


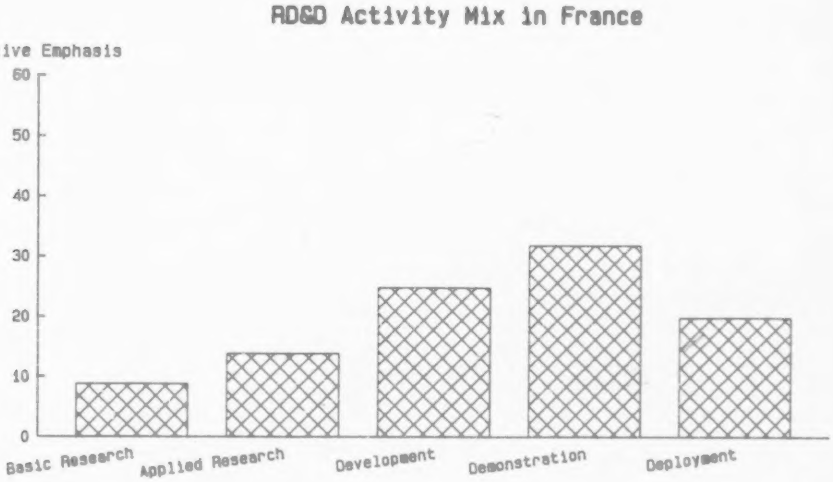


Source: Hagler, Bailly & Company, 1985

Exhibit 3

RD&D ACTIVITY IN FOUR EUROPEAN COUNTRIES





Source: Hagler, Bailly & Company.

In the remainder of this testimony, I will compare the organization of industrial energy conservation RD&D, the activities carried out, and the budgets allocated in the four European countries. The objectives of the comparison are to determine how each country's strategy has been implemented, to highlight emerging trends, to analyze changes over the 1981-1984 period, and to project likely developments.

ORGANIZATION OF RD&D

The organization of RD&D in each of the four countries has tended to change with changes in RD&D strategies. In general, organizational changes have resulted in:

- The centralization of RD&D activities and diffusion/deployment activities
- Better coordination with regions and the private sector
- Better coordination with research organizations.

In France, where the most drastic organizational change occurred, the creation of the French energy conservation agency -- AFME -- was a mark of the ambition of the 1982 French energy program. AFME was equipped to implement French energy conservation policy. It had a substantial staff and extensive regional representation through its 23 delegations that could ensure the continuity of its program in all parts of the country. AFME also centralized the R&D activities conducted by many nationalized companies, some of them with powerful resources. AFME's status as a super agency, an autonomous entity with its own budget, helped project a powerful image in favor of energy conservation. The quality of AFME's public relations department, the marketing expertise of its international department, and the savvy with which it has used the media are certainly important elements of AFME's successful promotion.

In the United Kingdom, where the strategy was oriented toward deployment activities, the organizational change took the form of a new energy efficiency office (EEO) within the U.K.'s Department of Energy. The EEO's objective was twofold: to spearhead a new coordinated drive for energy efficiency by embracing all government departments and to increase the visibility of conservation. EEO benefits from the help of five appointed marketing experts from the private sector and promotes close contacts with the regions through its network of regional energy efficiency officers.

In Sweden, demonstrations are now within the purview of the new National Energy Administration, while R&D activities have remained the responsibility of the National Swedish Board for Technical Development, STU. Such a split has complicated any attempt to fully coordinate the RD&D process and to quickly expand the process to embrace diffusion/deployment activities.

In the FRG, the RD&D organization has remained basically the same, with technical activities mainly in the hands of the German Ministry for Science and Technology (BMFT) and any deployment activities the responsibility of the Ministry of Economic Affairs (BMWi). The lack of change reflects the fact that German R&D activities have not expanded.

RD&D Activities

While all four countries are conducting demonstration activities and providing energy advisory services and training programs, the United Kingdom's R&D efforts are limited, and only France and the United Kingdom are active in deployment.

In conducting their R&D activities, France, the FRG, and Sweden have tried to:

- Diversify their work by supporting activities in other than their major industries (i.e., other than pulp and paper and iron and steel in Sweden; other than iron and steel and stone, clay, and glass in the FRG; and other than iron and steel and chemicals in France)
- Put more emphasis on generic R&D programs that are applicable to different industries; for example, the three countries have initiated extensive research in combustion, heat exchangers, grinding, separation techniques, and waste heat recovery technologies
- Put more emphasis on integrated processes than on the development of components

- Develop semi-commercial installations for testing purposes, which allows the same installations in a private plant to be used for several R&D projects.

In conducting demonstration activities, all four European countries are increasingly taking account of the technology's potential to increase productivity. The extent to which the demonstration is technical or economic in nature varies by country. In the FRG, demonstrations tend to serve more technical goals. In France and Sweden, they serve both, which explains why these countries support two types of demonstrations: first-of-a-kind demonstrations with more technical emphasis, and replication demonstrations to verify the economics of the new technology. In Sweden, the distinction becomes organizational as well. While the STU (the research agency) conducts first-of-a-kind demonstrations, replication demonstrations are within the purview of the National Energy Administration. In the United Kingdom, demonstrations focus on economic replication to prove the cost-effectiveness of the new technology.

First-of-a-kind demonstrations tend to be carefully planned as part of well-balanced RD&D programs, as -- for example -- in the FRG. When the focus is on replication demonstrations, the number and type of demonstrations do not always appear to respond to the same imperatives of careful selection, but tend to be selected on a more opportunistic basis. This problem may become more critical as R&D activities are increasingly oriented toward generic technologies that must be demonstrated in different industries.

The range of energy information services provided by the four European countries is wide, covering free energy audits, prefeasibility studies, and grants for corporate energy planning programs.

As part of their deployment activities, all the countries publish case studies to disseminate information on their demonstration projects. All countries except the FRG publish magazines and promotional inserts in the press. In addition, France and the United Kingdom support national conferences to promote energy-efficient technologies. France also promotes French products abroad through participation in international exhibits and logistical support to exporting firms.

RD&D Budgets

The FRG, France, and the United Kingdom increased their RD&D budgets significantly over the 1981-1983 period, and their 1984 budgets are between 24 percent and 34 percent higher than their 1981 levels (see Exhibit 4). The largest increase (34 percent) occurred in France. Although Sweden's 1984 RD&D budget is 6 percent lower than in 1981, 1982 and 1983 budgets were 54 percent and 40 percent, respectively, higher than in 1981. In comparison, U.S. government RD&D expenditures fell by 28 percent between 1981 and 1982. Furthermore, 1983 and 1984 funding levels were approximately 25 percent and 15 percent, respectively, below the 1981 level.

Future plans generally call for maintaining the current RD&D budget levels in France and in Sweden, for increasing them in the United Kingdom, and for slightly decreasing them in the FRG (see Exhibit 4).

When comparing the countries' RD&D budgets on the basis of GNP, we found that Sweden remains the leader, followed by the United Kingdom and France (see Exhibit 5). This ranking has not substantially changed since 1981. The FRG and the United States are, in relative terms, very similar, with the lowest expenditures per unit of GNP.

Comparing RD&D budgets in absolute terms in dollars can be extremely misleading, as declining exchange rates between European countries and the United States tend to show decreases in RD&D budgets (expressed in dollars) between 1981 and 1984, even though these budgets have increased in local currencies (see Exhibit 6).*

Government RD&D activities in Europe are always subcontracted and funded through cost-sharing contracts. At the R&D stage, government participation is generally considered sunk, and royalty-type agreements, if included in contracts, are generally not expected to return any substantial amount of money to the government. However, for demonstration projects, especially large ones, governments tend to structure their financial

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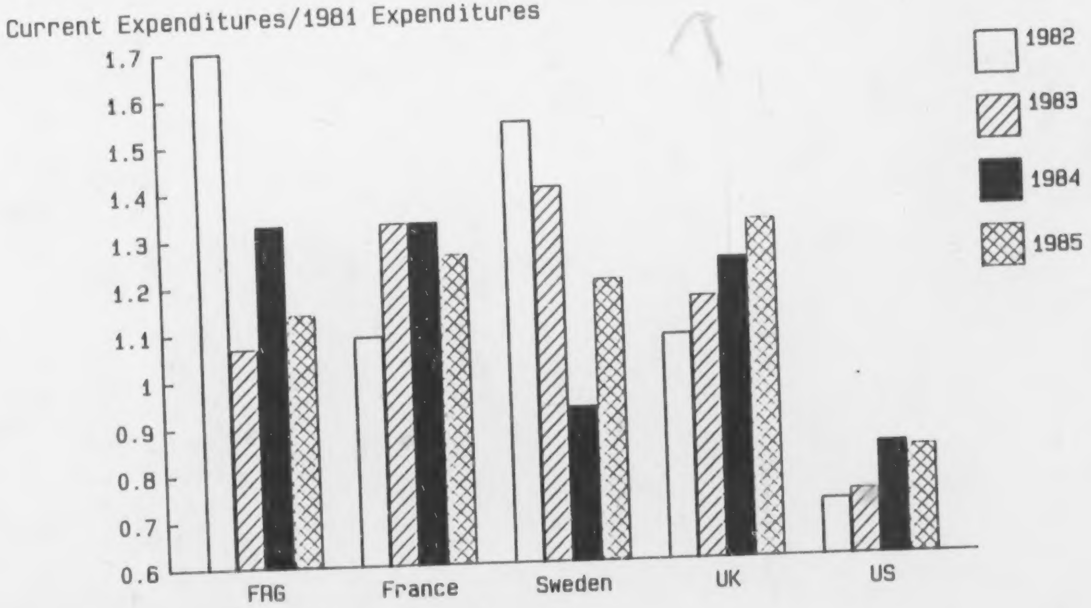
*Exhibits 7 and 8 present our estimates of annualized RD&D budgets for each country and some key economic data used to conduct our comparison of RD&D expenditures between countries.

Exhibit 4

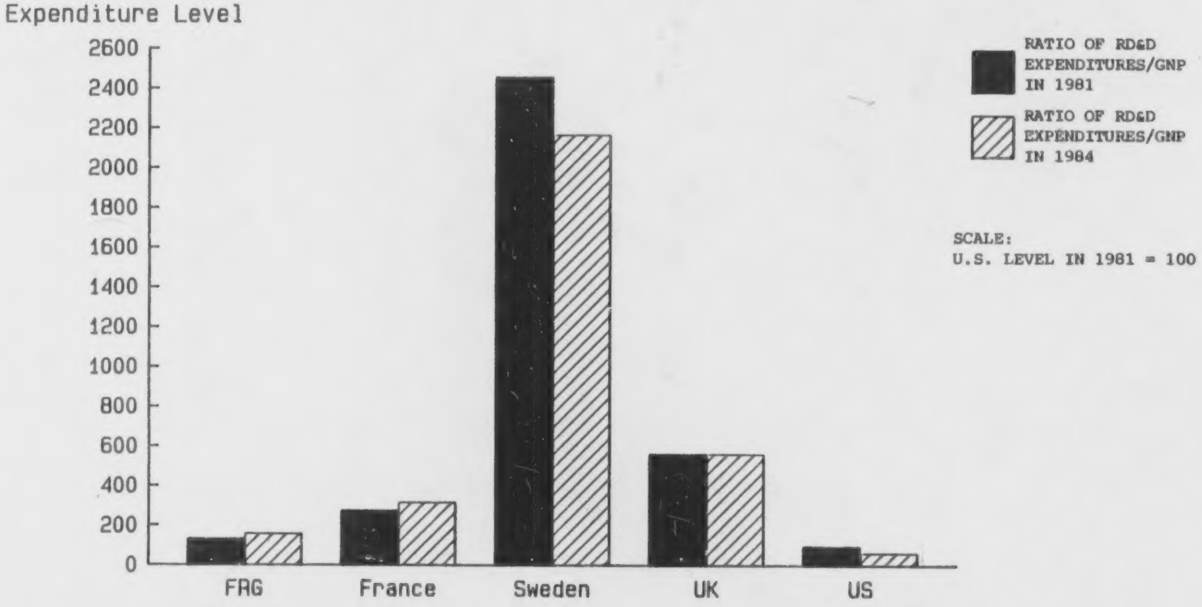
Comparing Past, Present and Future RD&D Expenditure Levels in Industrial Energy Conservation



Source: Hagler, Bailly & Company estimates – Data on annualized basis presented in Exhibit 7.

Exhibit 5

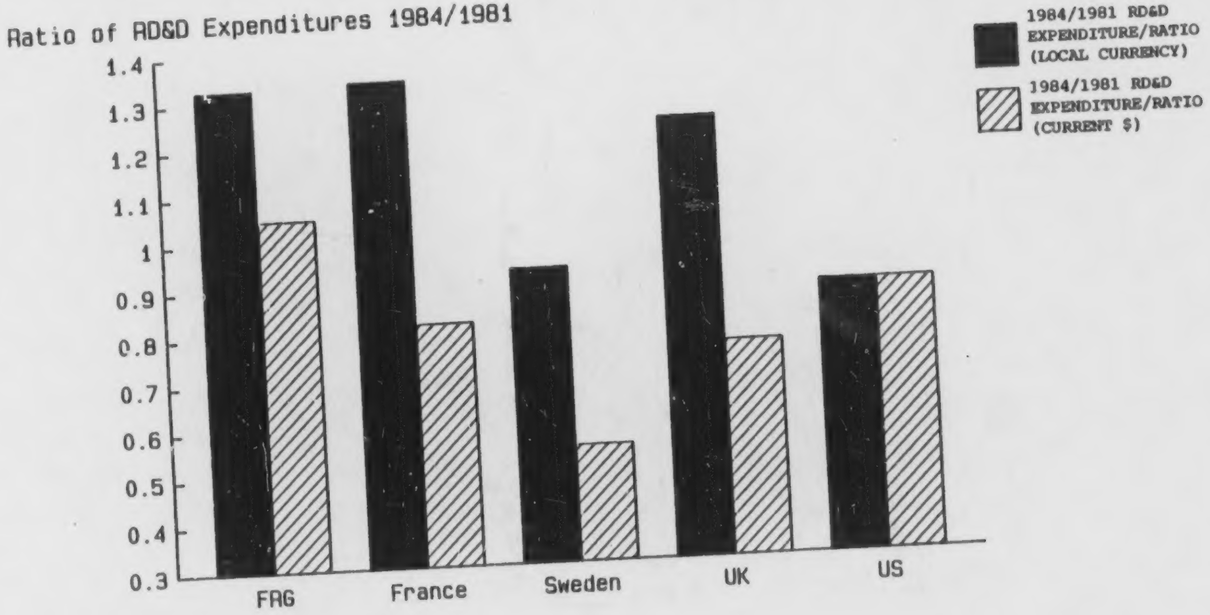
Comparing RD&D Expenditures in Industrial Energy Conservation per unit of GNP



Source: Hagler, Bailly & Company

Exhibit 6

Comparing 1981 and 1984 RD&D Expenditures in Local Currencies and in Current Dollars



Source: Hagler, Bailly & Company.

Exhibit 7

Annualized RD&D Budgets in Industrialized Energy Conservation

		Annualized budgets (million)				
Country	**Currency**	**1981**	**1982**	**1983**	**1984**	**1985^{e}**
FRG	DM	28.5	49.0	30.5	38.0	32.5
France	Fr	95.0	104.0	126.0	127.0	120.0
Sweden	Skr	171.0	263.0	239.0	160.0	200.0
United Kingdom	£	19.0	20.5	22.0	23.5	25.0
United States	$	39.4	28.6	29.3	33.5	33.5

e = estimated.

SOURCE: Hagler, Bailly & Company estimates.

Exhibit 8

Comparative Economic Factors

Country	Currency	Gross national product (billion) 1981	Gross national product (billion) 1984^e
FRG	DM	1573	1759
France	Fr	3111	3996
Sweden	Skr	522	553
United Kingdom	£	252	312
United States	$	2954	3660

Foreign Exchange Rates
(cents per unit of foreign currency)

Country	Currency	August 1981	January 1985
FRG	DM	39.99	31.55
France	Fr	16.72	10.31
Sweden	Skr	18.87	11.06
United Kingdom	£	182.07	112.48

e = estimated.

SOURCES: U.S. Federal Reserve System, Federal Reserve Bulletin; Main Economic Indicators, OECD; Wall Street Journal.

assistance as a conditional loan or grant, repayable depending on the economic performance of the project.

The level of cost sharing for an R&D project tends to average 50 percent in both France and Sweden; in the FRG, the government is trying to reduce the level of government funding to 40 percent. Government assistance for demonstrations is generally lower (in the 20- to 30-percent range), except in the FRG, where the funding rate of a demonstration project is not different from that of an R&D project.

In France, the FRG, and Sweden, R&D projects are seldom awarded on a competitive basis. Only the FRG indicated that it resorted to forms of competitive bidding when it knew enough about the status of the industry.

* * * * *

With strong RD&D support at home, foreign equipment suppliers can focus on their exports. The United States continues to be the plum, with an estimated market of $80 billion in energy-efficient industrial products over the next 10 years. European firms are increasingly focusing on such areas as energy-efficient electric motors, specialized heat exchangers, fluidized-bed boilers, cogeneration prime movers, and process controls. Fluidized-bed boilers are a good example: 1984 was the year when U.S. companies shopped for German, Swedish, or British technology -- to buy fluidized-bed boiler units, to acquire manufacturing licenses, or to form a joint venture. This is an important example because fluidized-bed combustion can be considered as the power generation technology for the next 20 years.

A recent study conducted by Hagler, Bailly, shows that the types of U.S. industrial equipment most vulnerable to replacement by foreign-made equipment are: foundry machinery; heat treatment equipment; electric motors; small cogeneration systems; centrifuges, filtering, and purifying equipment; mechanical power transmission equipment; and industrial food-, beverage-, and tobacco-processing machinery.

Moreover, if foreign companies can beat U.S. companies on their own turf, they can also beat them in the developing countries, where -- for energy-efficient industrial equipment alone -- we estimate the demand at another $80 billion.

When I testified before your Subcommittee in 1982, the administration was proposing to eliminate government support for industrial energy conservation R&D. At that time, I voiced my fear that it would be suicidal to eliminate the only government-funded civilian R&D program in industrial process efficiency, in light of our major trading partners' RD&D policies and programs.

I am pleased that the Congress did not go along with the administration's first request and that since then, the budget of the Office of Industrial Programs has stabilized at a level that, although modest (particularly when compared with the efforts of countries like the United Kingdom or Sweden), will nevertheless allow the United States to pursue some important development efforts in areas such as separation systems, materials processing, comminution, sensor and control systems, and industrial waste utilization. As a result, OIP's R&D activities will include many of the industrial energy conservation technologies that our European trading partners are pursuing. I would like, however, to make a few recommendations for strengthening OIP's program management.

First, this administration and the Congress of the United States should show a clear commitment to industrial energy conservation and assert the role of OIP in industrial productivity RD&D. Given the budget vagaries of the past 2-3 years, a clear signal should be given that OIP is here to stay and that a new climate of trust between OIP and the private sector can be fostered. Consideration for multi-year funding -- not necessarily higher funding -- could go a long way in strengthening OIP's role. Eventually, OIP may be able to project an image as strong as that of the AFME in France or the EEO in the United Kingdom. OIP's role in industrial productivity can be strengthened by allowing it to broaden its focus to include not only energy savings, but also savings in capital equipment, labor, and materials.

Second, OIP should seek the greater involvement of the private sector in its activities -- for example, in the evaluation of new energy conservation projects. There are probably means to avoid potential conflicts of interest, as the United Kingdom seems to have done.

Third, OIP should step up its information transfer activities and continue to monitor technology developments abroad.

Mr. FUQUA. Thank you very much.

Dr. Kelleher, we are pleased to hear from you now.

STATEMENT OF DR. EDWARD G. KELLEHER, DIRECTOR OF ENERGY AND PROCESS ENGINEERING AND ANALYTICAL SERVICES, CHAMPION INTERNATIONAL CORP., WEST NYACK, NY

Dr. KELLEHER. Mr. Chairman and members of the committee, I am pleased to have the opportunity to speak to you on behalf of the efforts of the Office of Industrial Programs in the Department of Energy.

I am Edward G. Kelleher, director of energy and process engineering and analytical services for Champion International, and I am appearing on behalf of Robert L. Myers, vice president of technology, who has submitted a written statement to you.

Since the merger of St. Regis Corp. with Champion International last fall, Champion is one of the largest paper companies in the world, with sales of approximately $7 billion annually. Champion owns or manages approximately 9 million acres of woodlands, 21 paper mills in 13 different States, and converting plants in almost every State in the Union.

The technology division of Champion is responsible for the generation and implementation of new product and new process technology for our company, including energy-saving innovations. I would like to outline for you some of the motivations and some of the problems inherent in the adoption of new energy technologies in our industry.

I would like to make two specific points. First, I believe that conservation still represents the most immediate and surest way of achieving significant energy savings in our industry. Second, while many energy conservation technologies have been discovered or are under development, their potential will never be realized until and unless someone demonstrates these technologies at essentially full operating scale.

The Department of Energy's Office of Industrial Programs has been instrumental in moving a number of these technologies forward, and I believe that they have played, and should continue to play, a significant role.

St. Regis Corp., now Champion, has been associated with the Department of Energy for a number of years, and I can say without reservation that the programs that we have conducted in cooperation with the DOE would not have been conducted in the absence of their support.

In 1972, an energy conservation program was initiated in our industry. By 1983, we had reduced the energy requirements from an industry average of over 19 million Btus per ton of pulp and paper produced to 12.7 million Btus per ton, or a reduction equivalent to a barrel of oil for each ton of pulp and paper produced.

Based on current production of 70 million tons of pulp and paper annually, those efforts represent a savings of about 70 million barrels of oil. This is an outstanding achievement, in our view, but still leaves a significant amount of energy that is required to make paper.

The paper industry is still in the unenviable position of being the No. 1 user of oil among manufacturing industries. We believe that current ongoing programs could result in further reductions if they can be implemented.

In the kraft process segment of our industry, purchased fossil fuel and energy comprises 45 percent of the total energy requirements. The other 55 percent is obtained from burning wood residues and spent pulping liquors, a term that I will explain in a moment. In a modern kraft mill, up to 70 percent of the energy requirements can be met from wood residues and pulping liquors.

In the production of kraft fiber, which is the strongest fiber we know how to make and is ubiquitous in everything from newsprint, magazines, sacks, and corrugated boxes to the paper on your desk, we literally cook the wood in a pressure vessel with a solution of strong caustic and other chemicals. The strong caustic liquor dissolves away approximately 50 percent of the dry weight of the wood, liberating the fiber for subsequent papermaking.

The dissolved wood substances, together with the remaining inorganic chemicals, are concentrated by evaporation to a high solids level where they take on the appearance of bunker C fuel oil. They are fired in a specially designed furnace where both the energy present and the residual inorganic chemicals are recovered.

This boiler, which is called a Tomlinson furnace, after its inventor, has been refined and optimized over the last 50 years and is an integral and vital part of the kraft process.

However, even a state-of-the-art furnace is thermally inefficient. It also has serious safety problems, due primarily to the fact that inorganic chemicals are removed as a molten smelt. When water from any source, such as the boiler tubes, comes in contact with this smelt, serious explosions can and do occur.

Consequently, our industry is ready and eager for an alternative which would provide greater safety and improved energy efficiency. We are currently working on a novel alternative process in conjunction with DOE and Rockwell International which would provide significantly improved energy efficiency and would eliminate the safety problem. Had it not been for the encouragement and support of the DOE, I can assure you that we would not be at this stage of development at this time.

You will recall that I said that many of the energy-saving processes that have already been discovered or are under development will not be utilized until someone demonstrates their economic and technical utility at essentially full scale.

In my judgment, the largest single barrier to the introduction of any innovative energy-saving technology is the large capital cost and the attendant high risk associated with the necessity of demonstrating it on a plant scale.

Energy conservation technologies must compete for capital dollars and research dollars with all other segments of the business. While the reduction in energy prices we have seen recently helps reduce our operating costs, it also reduces our ability to get capital and research dollars for energy projects.

Today a typical kraft mill represents an investment of anywhere from $750,000,000 to $1 billion, and it consists of a series of unit operations closely tied together.

The mill must be operated at over 90 percent of capacity throughout the year in order to be profitable. If any single part of this chain fails to operate, the entire investment is idle. Hence, you can understand our preoccupation with the demonstration of the reliability and operability of any new technology.

We are approaching the demonstration phase in our current project. A demonstration plant may cost as much as $20 million to $25 million. An investment of this magnitude in an unproven technology is beyond the scope of any single paper company, no matter how large.

Consequently, as we approach the demonstration phase, we hope and expect to form a consortium of interested parties, including the DOE, to share the risks and to share the benefits of this technology with the industry.

We hope by this method of combined industry and DOE approach to reduce the financial risk to acceptable levels. We believe that the Department of Energy's industrial program is a keystone in this type of effort.

I believe that the process industries such as pulp and paper will continue to face unique problems in the introduction of new energy-saving technologies, and I would hope that this committee would continue to investigate initiatives to facilitate the adoption of these technologies.

I thank you for the opportunity of speaking to you, and I would be pleased to answer any questions.

[The prepared statement of Dr. Myers follows:]

TESTIMONY OF DR. ROBERT L. MYERS

VICE PRESIDENT - TECHNOLOGY

CHAMPION INTERNATIONAL, INC.

TO THE

ENERGY DEVELOPMENT AND APPLICATIONS

COMMITTEE ON

SCIENCE AND TECHNOLOGY

UNITED STATES HOUSE OF REPRESENTATIVES

Washington, D. C. 20515

March 6, 1985

HOUSE SCIENCE & TECHNOLOGY COMMITTEE
SUB-COMMITTEE ON ENERGY DEVELOPMENT AND APPLICATION

MR. CHAIRMAN, MEMBERS OF THE COMMITTEE, LADIES AND GENTLEMEN. I AM VERY PLEASED WITH THIS OPPORTUNITY TO SPEAK TO YOU ON BEHALF OF THE PROGRAMS IN THE OFFICE OF INDUSTRIAL PROGRAMS AND CONSERVATION IN THE DEPARTMENT OF ENERGY. I AM ROBERT L. MYERS, VICE PRESIDENT TECHNOLOGY FOR CHAMPION INTERNATIONAL INCORPORATED, WHICH, SINCE ITS MERGER WITH THE ST. REGIS CORPORATION LAST FALL MAKES CHAMPION INTERNATIONAL ONE OF THE LARGEST PAPER COMPANIES IN THE WORLD, WITH SALES OF APPROXIMATELY 7 BILLION DOLLARS ANNUALLY. CHAMPION OWNS OR MANAGES APPROXIMATELY 9 MILLION ACRES OF WOODLANDS, AND 21 PAPER MILLS IN 13 STATES AND CONVERTING PLANTS IN ALMOST EVERY STATE IN THE UNION.

I AM RESPONSIBLE FOR THE GENERATION AND IMPLEMENTATION OF NEW PRODUCT AND NEW PROCESS TECHNOLOGY FOR OUR COMPANY, INCLUDING ENERGY-SAVING INNOVATIONS. I WOULD LIKE TO OUTLINE FOR YOU SOME OF THE ENERGY-SAVING POTENTIALS INHERENT IN THE ADOPTION OF NEW PROCESS TECHNOLOGIES IN OUR INDUSTRY AND SOME OF THE PROBLEMS THAT ARE ASSOCIATED WITH THAT ADOPTION.

I WOULD LIKE TO MAKE TWO SPECIFIC POINTS. FIRST OF ALL, I BELIEVE THAT CONSERVATION STILL REPRESENTS THE MOST IMMEDIATE AND SUREST WAY OF ACHIEVING SIGNIFICANT ENERGY SAVINGS IN OUR INDUSTRY; AND SECONDLY, THAT WHILE MANY PROCESSES HAVE BEEN DISCOVERED OR ARE UNDER DEVELOPMENT, THEIR POTENTIAL WILL NEVER BE REALIZED UNLESS AND UNTIL SOMEONE DEMONSTRATES THESE TECHNOLOGIES AT ESSENTIALLY

FULL OPERATING LEVELS. THE DEPARTMENT OF ENERGY'S OFFICE OF INDUSTRIAL PROGRAMS AND CONSERVATION HAS BEEN INSTRUMENTAL IN MOVING A NUMBER OF THESE TECHNOLOGIES FORWARD, AND I BELIEVE THAT THEY HAVE AND SHOULD CONTINUE TO PLAY A SIGNIFICANT ROLE IN INDUSTRY'S ACHIEVING THESE RESULTS. I SHOULD REMARK THAT THE ST. REGIS CORPORATION HAS BEEN ASSOCIATED WITH THE DEPARTMENT OF ENERGY FOR A NUMBER OF YEARS AND I CAN SAY WITHOUT RESERVATION THAT THE PROGRAMS THAT WE HAVE OPERATED IN COOPERATION WITH THE DOE WOULD NOT HAVE EVER BEEN OPERATED IN THE ABSENCE OF THEIR SUPPORT AND I HOPE THAT SOME OF THE REASONS FOR THIS WILL BECOME APPARENT.

IN 1972 AN ENERGY CONSERVATION PROGRAM WAS INITIATED IN OUR INDUSTRY. IN SPITE OF THE ADDITION OF LARGE ENERGY-CONSUMING ELEMENTS ASSOCIATED WITH AIR AND WATER COMPLIANCE PROGRAMS WE HAD BY 1983 REDUCED THE ENERGY REQUIREMENTS FROM AN INDUSTRY AVERAGE OF 19 MILLION BTU'S PER TON OF PAPER TO 12.7 MM BTU'S, OR A TOTAL SAVINGS OF A BARREL OF OIL FOR EACH TON OF PULP AND PAPER. THIS IS AN OUTSTANDING ACHIEVEMENT BUT STILL LEAVES AN IMPRESSIVE AMOUNT OF ENERGY THAT IS REQUIRED TO MAKE PAPER. WE BELIEVE THAT CURRENT ONGOING PROGRAMS COULD RESULT IN FURTHER REDUCTIONS PER TON OF PRODUCT. BASED ON CURRENT U. S. PRODUCTION OF PAPER OF 70 MILLION TONS, THESE ACHIEVEMENTS REPRESENT A TOTAL REDUCTION OF ALMOST 70 MILLION BARRELS OF OIL ANNUALLY.

THE PAPER INDUSTRY IS IN THE UNENVIABLE POSITION OF BEING THE NUMBER ONE USER OF FUEL OIL AMONG MANUFACTURING INDUSTRIES.

IN THE LARGE KRAFT PROCESS SEGMENT OF OUR INDUSTRY, PURCHASED FOSSIL FUEL COMPRISES ONLY 45% OF THIS SEGMENT OF OUR INDUSTRY ENERGY REQUIREMENTS. THE OTHER 55% IS OBTAINED FROM BURNING WOOD RESIDUES AND SPENT PULPING LIQUORS, A TERM THAT I WILL EXPLAIN IN A MOMENT. A MODERN KRAFT MILL CAN SUPPLY UP TO 70% OF THEIR FUEL NEEDS FROM WOOD RESIDUES AND SPENT PULPING LIQUOR. WHERE AVAILABLE, OTHER SOURCES OF FOREST RESIDUES AUGMENT THOSE GENERATED BY DEBARKING AND CHIPPING AND IN THESE CASES, EVEN HIGHER LEVELS OF SELF-SUFFICIENCY CAN BE ACHIEVED.

IN THE PRODUCTION OF KRAFT FIBER, WHICH IS THE STRONGEST FIBER WE KNOW HOW TO MAKE AND IS UBIQUITOUS IN EVERYTHING FROM NEWSPRINT, MAGAZINES, SACKS AND CORRUGATED BOXES AND INCLUDING THE PAPER THAT IS ON YOUR DESK BEFORE YOU. TO MAKE KRAFT FIBER FROM WOOD CHIPS WE LITERALLY COOK THE WOOD IN A PRESSURE VESSEL WITH A SOLUTION OF STRONG CAUSTIC AND OTHER CHEMICALS. IN THIS PROCESS THE STRONG CAUSTIC LIQUOR DISSOLVES AWAY APPROXIMATELY 50% OF THE DRY WEIGHT OF WOOD, LIBERATING THE FIBER FOR SUBSEQUENT PAPERMAKING. THE DISSOLVED WOOD SUBSTANCES, TOGETHER WITH THE REMAINING INORGANIC CHEMICALS ARE CONCENTRATED BY EVAPORATION TO A HIGH SOLIDS LEVEL WHERE THEY TAKE ON THE APPEARANCE OF BUNKER C FUEL OIL. THEY ARE FIRED IN A SPECIALLY DESIGNED BOILER WHERE BOTH THE ENERGY PRESENT IN THE CARBOHYDRATE AND LIGNINS AND THE INORGANIC CHEMICALS ARE RECOVERED. THIS PROCESS WHICH IS CALLED THE TOMLINSON FURNACE AFTER ITS INVENTOR HAS BEEN REFINED AND OPTIMIZED OVER THE LAST 50 YEARS AND IS AN INTEGRAL AND VITAL PART OF THE KRAFT PROCESS.

HOWEVER, IN ITS PRESENT STATE-OF-THE ART IT IS THERMALLY INEFFICIENT AND HAS SERIOUS SAFETY PROBLEMS, DUE PRIMARILY TO THE FACT THAT INORGANIC CHEMICALS ARE RECOVERED AS A MOLTEN LAVA OR SMELT. WHEN WATER FROM ANY SOURCE, SUCH AS THE BOILER TUBES, COMES IN CONTACT WITH THIS SMELT, SERIOUS EXPLOSIONS CAN AND DO OCCUR. CONSEQUENTLY, OUR INDUSTRY IS READY AND EAGER FOR AN ALTERNATIVE WHICH WOULD PROVIDE GREATER SAFETY AND IMPROVED ENERGY RECOVERY. WE ARE CURRENTLY WORKING ON A NOVEL PROCESS IN CONJUNCTION WITH ROCKWELL INTERNATIONAL ON AN ALTERNATIVE WHICH WOULD PROVIDE SIGNIFICANTLY IMPROVED ENERGY RECOVERY AND EFFICIENCY AND WOULD ELIMINATE THE SAFETY PROBLEM. HAD IT NOT BEEN FOR THE ENCOURAGEMENT FROM THE DOE, I CAN ASSURE YOU THAT WE WOULD NOT BE AT THIS STAGE OF DEVELOPMENT AT THIS POINT IN TIME.

YOU WILL RECALL THAT I SAID AT THE OUTSET THAT MANY OF THE ENERGY SAVING PROCESSES THAT HAVE ALREADY BEEN DISCOVERED OR ARE UNDER DEVELOPMENT WILL NOT BE UTILIZED UNTIL SOMEONE DEMONSTRATES THEIR ECONOMIC AND TECHNICAL UTILITY AT ESSENTIALLY A FULL OPERATING LEVEL.

IN MY JUDGEMENT THE LARGEST SINGLE BARRIER TO THE INTRODUCTION OF ANY INNOVATIVE ENERGY-SAVING TECHNOLOGY IS THE LARGE CAPITAL COST AND THE ATTENDANT HIGH RISK ASSOCIATED WITH THE NECESSITY OF DEMONSTRATING THIS FULL PLANT SCALE. UNLIKE A PRODUCT ORIENTED BUSINESS WHICH CAN LIMIT ITS RISKS AND EXPOSURE THROUGH TEST MARKET AND STEP-WISE ADDITION OF CAPACITY AS REQUIRED, THE PROCESS INDUSTRY SUCH AS KRAFT PAPER CAN ONLY BE ECONOMIC AT LARGE SCALE LEVELS WHERE THE CAPACITY INCREMENTS ARE VERY LARGE.

TODAY A TYPICAL SOUTHERN KRAFT MILL REPRESENTS AN INVESTMENT OF ANYWHERE FROM 3/4 TO A BILLION DOLLARS, AND CONSISTS OF A SERIES OF UNIT OPERATIONS CLOSELY TIED TOGETHER WITH MANY FEEDBACK LOOPS. ADDITIONALLY A KRAFT MILL MUST BE OPERATED AT OVER 90% OF CAPACITY THROUGHOUT THE YEAR IN ORDER TO BE PROFITABLE. IF ANY SINGLE PART OF THIS CHAIN FAILS TO OPERATE THE ENTIRE INVESTMENT IS IDLED. HENCE, OUR PREOCCUPATION WITH THE DEMONSTRATION OF THE RELIABILITY AND OPERABILITY OF ANY NEW TECHNOLOGY. WE ARE APPROACHING THAT PHASE IN OUR CURRENT PROJECT.

A DEMONSTRATION PLANT MAY COST AS MUCH AS 20-25 MILLION DOLLARS. AN INVESTMENT OF THIS MAGNITUDE IN AN UNPROVEN TECHNOLOGY IS BEYOND THE SCOPE OF ANY SINGLE PAPER COMPANY, NO MATTER HOW LARGE. CONSEQUENTLY, AS WE APPROACH THE DEMONSTRATION PHASE WE WOULD EXPECT TO FORM A CONSORTIUM OF INTERESTED PARTIES INCLUDING THE DOE TO SHARE THE RISK AND SHARE THE BENEFITS OF THIS TECHNOLOGY WITH THE INDUSTRY. WE HOPE THAT BY THIS METHOD OF A COMBINED INDUSTRY AND DOE APPROACH TO REDUCE THE FINANCIAL RISK TO ACCEPTABLE LEVELS. WE BELIEVE THAT THE DEPARTMENT OF ENERGY'S INDUSTRIAL PROGRAM IS A KEYSTONE IN THIS TYPE OF PROGRAM. I BELIEVE THAT THE PROCESS INDUSTRIES SUCH AS PULP AND PAPER FACE UNIQUE PROBLEMS IN THE INTRODUCTION OF NEW ENERGY-SAVING TECHNOLOGIES AND I WOULD HOPE THAT THIS COMMITTEE WOULD CONTINUE TO INVESTIGATE INITIATIVES TO FACILITATE THE ADOPTION OF THESE NEW TECHNOLOGIES.

MAY I THANK YOU FOR THIS OPPORTUNITY AND I WOULD BE PLEASED TO ATTEMPT TO ANSWER ANY QUESTIONS THAT YOU MAY HAVE.

Mr. FUQUA. Thank you very much.

Dr. Leonard?

Mr. RITTER. Mr. Chairman?

Mr. FUQUA. Mr. Ritter?

Mr. RITTER. I would appreciate the opportunity to introduce my constituent from Lehigh Valley.

Dr. Jim Leonard is a new man on the block in the steel industry, and he brings with him knowledge of machines and tools and how to put them to work. He brings with him knowledge of the academic world, having worked there. He has been a department chairman in an industry-oriented academic program, and he has worked with the Government as well. So I think he is in a particularly good position to comment on the subject that is encompassed by his testimony.

I thank the chairman.

Mr. FUQUA. Thank you very much.

STATEMENT OF DR. JAMES H. LEONARD, VICE PRESIDENT FOR TECHNOLOGY, BETHLEHEM STEEL CORP., PITTSBURGH, PA, AND CHAIRMAN, COMMITTEE ON TECHNOLOGY, AMERICAN IRON & STEEL INSTITUTE

Dr. LEONARD. Thank you, Mr. Chairman. Thank you, Congressman Ritter and other members of the subcommittee.

I not only serve as vice president for technology of Bethlehem Steel Corp., but I am also chairman of the Committee on Technology for the American Iron & Steel Institute, despite being the new kid on the block, by the way, and I am appearing on behalf of that institute, known as AISI, and Bethlehem.

I am here to speak in support of the fiscal year 1986 budget for the industrial programs portion of the conservation and renewable energy program of DOE. As part of this program my company, in partnership with United States Steel, entered into a cooperative agreement with DOE last September to develop a new technology to produce sheet steels with a major energy savings. This savings is measured by about two-tenths of a quad per year, and to put that into something meaningful, that is about 15 percent of the total energy consumption of the entire steel industry, so that is quite significant.

This technology, if successful, will yield a capital and operating cost savings of like proportions, something like $35 a ton capital cost and $45 per ton operating cost, both of which are in the 10- to 15-percent range of savings, so it is quite significant.

The total estimated cost of the 5-year development program is $32.9 million, with United States Steel and Bethlehem Steel cost-sharing up to $4.1 million of that amount. The approach is to cast thin steel sections one-half to 1 inch in thickness using what are called moving-mold casters, followed by one or two steps of hot rolling to about one-tenth inch in thickness.

This results in what is known as hot band in the industry. This could be applied commercially in some instances and sometimes further cold rolled and heat treated into other existing commercial applications.

Now, the Federal funding for this program will be repaid from the use and sale of the technology developed. The fiscal year 1986 budget of the Industrial Programs Office contains funding for continuation of this development program, and obviously we endorse that and wanted to mention it.

But we would like to call attention of this subcommittee for its consideration to another program which could perhaps come within DOE's conservation and renewable energy program scope, and that is the proposed joint collaboration research program involving the Federal national laboratories, the National Bureau of Standards, and the steel industry collectively in what is called the Keyworth initiative, which has been recommended by the Office of Science and Technology Policy for inclusion in the fiscal year 1986 budget.

I would like to give you a little background on this proposal and its current status. The May 1983 report of the White House Science Council's Federal Laboratory Review Panel, known as the Packard report, strongly recommended increasing the collaboration of the Federal laboratories with universities and industry.

Subsequently, Dr. George Keyworth, Science Advisor to the President, and Mr. Howard Love, chairman of National Intergroup, as members of the Presidential Committee on Industrial Competitiveness, identified the possibility that this recommendation could be related to the long-range problems of the domestic steel industry.

In a February 3, 1984, presentation to this Presidential committee, Mr. Love suggested—and I am paraphrasing—that steel firms come together to identify an agenda for R&D on what are called leapfrog technologies, and then join with the national labs to realize that agenda. The stress was placed on the fact that this must be leapfrog technology, something that will get us out ahead of the competition in technology development worldwide in steel.

The vision here is of a steel industry of the future in which there would be no blast furnaces, no coke ovens, and none of those mile-long rusting rolling mills which are so familiar to all of us today, and in place we would have a two-step process which would yield high-quality, higher yield product and at smaller scales, all with greater flexibility and automation.

The reason this is possible is that even though we in this country have the highest labor cost, we also have in our favor the best science and technology capability and personnel in the world. Let's simply take advantage of that treasure and utilize it for the rejuvenation of what we believe to be a basic and vital industry.

On February 4, 1984, members of the Iron and Steel Institute Committee on General Research joined Mr. Love and Dr. Keyworth for a meeting in the White House, and shortly thereafter joint exploratory studies commenced between certain national laboratories and steel industry scientists. The nature of this joint effort was reviewed by Dr. Keyworth in his speech at the Steel Institute general meeting on May 24, 1984.

Then during the latter half of 1984, four joint task groups came together under the direction of a joint steering committee and made an intensive and well-documented search for new approaches in steelmaking, in steel casting, in product development and process control engineering.

The enthusiasm of the steel industry participants in this long-range and analytical effort has been sustained by rapid, high-quality responses from the scientists at the Argonne and Oak Ridge National Laboratories and from the National Bureau of Standards. There has also been all-around recognition that the steel industry is limited in its own ability to commit its severely limited resources to such really long-term objectives.

As a result of all of these efforts, opportunities for long-range and novel technology development were identified in two particular areas. The first of these is known as direct production of liquid steel from iron ore, and the second is known as casting of near net shape solids.

Now, Professor Elliott, to my right, will be describing some of those in more detail, so I will not do that. I wish only to say that this two-step process that is envisioned, if successful, will achieve a superior steel product with minimal capital equipment, energy, and operating costs relative to the technology of today.

To underscore that point, one way of looking at this is, Bethlehem Steel is currently engaged in installing two current technology steel casting machines, one at each of its two major plants, for a total cost of approximately half a billion dollars. Now, to compare that, the total value of Bethlehem Steel Corp. on today's stock market for all its outstanding stock is something less than $1 billion.

So every time we install one of those, we are literally betting the company and then some, and if we can find a new technology in the future that will get that price tag down and at the same time produce higher quality steel, that is what we are going to need to survive into the 21st century, and I believe we must survive in this country in steel.

Now, the lead national laboratory for these projects as currently envisioned will be Argonne, which has extensive capabilities in development and application of a variety of related technologies including magnetohydrodynamics, metallurgy, slag-refractory interactions, and complex chemical and electromechanical systems.

Oak Ridge will play a major role in thermomechanical aspects of these projects, especially in microstructure evaluation of the finished product. The National Bureau of Standards will participate in the area of advanced instruments and sensor development as an extension of an ongoing cooperative AISI and NBS sensor development work.

By October 1984, the proposed program had been developed to the point that funding needs could be identified. This is shown in the attached Federal laboratory and steel industry initiative called "Summary and Work Plans" dated September 1984. So the detailed homework has been done.

A total of $14 million per year for 1985 and 1986 was recommended, broken down as follows: $10 million per year from the Department of Energy through the national laboratories, $2.5 million per year from the Department of Commerce through the National Bureau of Standards, and $1.5 million per year from the steel industry itself through AISI.

The AISI funding will support 15 steel industry scientists who will work side by side with Government scientists at the national laboratories and at the Bureau of Standards. The importance of this close working relationship simply cannot be overemphasized. It could serve as a prototype for future joint Government and industry, what we might call hands-on collaborative efforts, where we, in the industry, bring the know-how, together with the fine advanced technology in the national laboratories.

In November, the AISI board of directors approved participation of this funding level for 2 years, with half the funds to come from the AISI budget—and at the expense of existing programs, by the way—and the other half from individual participating companies.

Last December, Argonne National Laboratory had identified 12 scientists to work on their portion of the first year's program. Enthusiasm on the part of the Government and industry scientists was quite high.

The proposed research program was submitted by the Office of Science and Technology to the Office of Management and Budget for approval in December, with the strong endorsement of Argonne, NBS, and AISI, among others.

Unfortunately, because of budget reduction efforts at OMB, no funds were included for DOC or DOE for this program either in 1985 supplemental or 1986 budgets. We are advised that Congress will have to approve funding as a special additional or reallocated item in the 1986 budget.

Speaking for AISI, we recommend that this subcommittee consider authorizing DOE funding for this initiative in the fiscal year 1986 budget. In so doing, we want to emphasize that, as its popular title, the Keyworth initiative, implies, this proposed research program has already received emphasis not only through the industry but through Government sponsorship, together with the strong encouragement of the Office of Science and Technology Policy, the national labs, and the Bureau of Standards, as well as the steel industry.

We are all now enthusiastic supporters of this program, and a great deal of the preliminary planning has been done. We believe the merits of this idea are self-evident, and in addition to the particular technology it could generate, we believe this is also important as a model for future industry-Government collaborative efforts to improve the competitiveness of basic U.S. industries.

There simply must be some way to find funding for this modestly sized but pioneering endeavor which will be a unique and once-in-a-lifetime opportunity to rejuvenate and restore technology leadership to a vital but struggling basic industry, doing this through a unique, what I will call proactive, bottom-up collaborative alliance of Government and industry.

Thank you, Mr. Chairman and committee members.

[The prepared statement of Dr. Leonard follows:]

Statement by James H. Leonard, Vice President, Technology, Bethlehem Steel Corporation, Before House of Representatives' Subcommittee on Energy Development and Applications, March 7, 1985

My name is James H. Leonard, Vice President for Technology, Bethlehem Steel Corporation. I am also Chairman of the American Iron and Steel Institute Committee on Technology. I am appearing today on behalf of AISI and Bethlehem Steel. AISI is the principal trade association of the domestic iron and steel industry whose 56 member companies account for approximately 90% of the nation's steel production capability. Bethlehem Steel Corporation is a large American steel producer with an annual steel production capability of 17.6 million tons.

It is a pleasure to appear before this Subcommittee on the subject of the FY 1986 budget for the Industrial Programs portion of the Conservation and Renewable Energy program of DOE. As part of this program, my company, in partnership with U.S. Steel, entered into a cooperative agreement with DOE last September to develop a new technology to produce sheet steels with a major energy savings (approximately 0.2 QUAD/year by 1990) and with a significant capital and operating cost savings ($35/ton and $45/ton, respectively) over existing steel slab casting technology. The total estimated cost of the five year development program is $32.9 million with U.S. Steel and Bethlehem cost sharing up to $4.1 million. The approach is to cast thin steel sections one-half to one inch in thickness using moving-mold casters, followed by hot rolling to about 0.1 inch in thickness. The resulting steel hot band could be commercially applied directly or subsequently cold rolled and heat treated for other commercial applications. The federal funding for this program will be repaid from the use and sale of the technology developed. The FY 1986 budget of the Industrial Programs Office contains funding for continuation of this development program, which we obviously endorse.

We would also like to call to the attention of this Subcommittee for its consideration another program which would most appropriately fall within DOE's conservation and renewable energy program. This proposed joint collaborative research program involving the National Laboratories, the

National Bureau of Standards and the steel industry - the so-called Keyworth Initiative - has been recommended by the Office of Science and Technology Policy for inclusion in the FY 1986 budget. I would like to give you some background on this proposal and its current status.

The May 1983 report of the White House Science Council's Federal Laboratory Review Panel, known as the "Packard Report," strongly recommended increasing the collaboration of the federal laboratories with universities and industry. Subsequently, Dr. G. A. Keyworth, Science Advisor to the President, and Howard M. Love, Chairman of National Intergroup, as members of the Presidential Committee on Industrial Competitiveness (PCIC), identified the possibility that this recommendation could be related to the long-range problems of the domestic steel industry. In a February 3, 1984, presentation to the PCIC, Mr. Love made the following suggestion:

> What I am proposing, then, is that steel firms come together to identify an agenda for R&D on leapfrog technologies, and then join with the National Labs to realize that agenda. Let me stress that this must be R&D on leapfrog technologies. If we fall into the rut of 'business and usual,' and merely agree on a modest agenda on R&D for incremental improvements, we will have failed. Let's envision a steel industry where we throw away the blast furnaces, throw away coke ovens, and develop entirely new ways of making a higher quality, higher yield product, at smaller scales, with greater flexibility and more automation.
>
> Let me also stress that by seeking a technological solution, we are building upon our national strengths. We can't compete with the third world on the cost of labor or capital. The one thing we have in our favor is the best science and technology base in the world. Let's take advantage of the base; let's utilize it for the benefit of our basic industries.

On February 8, 1984, members of the Committee on General Research joined Mr. Love and Dr. Keyworth for a meeting in the White House; and, shortly thereafter, joint exploratory studies between certain National Laboratories and steel industry scientists were underway. The nature of this joint effort was reviewed by Dr. Keyworth in his speech at the AISI General Meeting on May 24, 1984.

During the latter half of 1984, four joint task groups under the direction of a Joint Steering Committee made an intensive and well documented search for new approaches in steelmaking, casting, product development, and control engineering. The enthusiasm of the steel industry participants in these long-range analyses has been sustained by rapid, high-quality responses from the scientists at the Argonne and Oak Ridge National Laboratories and the National Bureau of Standards. There has also been all-around recognition that the steel industry is limited in its ability to commit its severely limited resources to long-term objectives. As a result of these studies, opportunities for long range and novel technological development were identified in two areas:

A. Direct Production of Liquid Steel from Iron Ore

The first objective is to develop for the mid-term (commercialization within about 15 years) an optimized process for the direct carbo-thermal reduction of iron ore to steel. The process sought would leapfrog existing technology by replacing the conventional coke oven and blast furnace and possibly also the subsequent steelmaking step. Coal is the preferred reductant in the process because of its inherent cost advantage over other fuels, and the process evaluation and development will emphasize the utilization of a wide range of domestic coals and iron ores as feedstocks. The ideal target process will result in a 50% reduction in capital costs and a 30% reduction in operating and maintenance costs as compared with present technology.

B. Casting of Near Net Shape Solids

Because molds intrinsically have the potential to produce defects in cast metal, the main objective of this task will be to develop "mold-less" processes, especially for steel strip. The most promising approach will adapt electromagnetic containment currently in use for casting of aluminum. Further objectives are to (1) investigate methods for removal of nonmetallic inclusions to facilitate near-net-shape casting and (2) develop the solidification models, sensors, and the thermomechanical processing steps required to produce the requisite finished properties from the near-net-shape cast structure. This "model process" would achieve a superior product with minimal capital equipment, energy, and operating costs.

The lead National Laboratory for these projects, as currently envisioned, would be Argonne, which has extensive capabilities in development and application of a variety of related technologies, including magnetohydrodynamics, metallurgy, slag-refractory interactions and complex chemical and electromechanical systems. Oak Ridge would play a major role in the thermo-mechanical aspects of these projects, especially in microstructure evaluation. The National Bureau of Standards would participate in the area of advanced sensor development, as an extension of ongoing AISI/NBS sensor development work.

By October of 1984 the proposed research program had been developed to the point that funding needs could be identified (see attached "Federal Laboratory-Steel Industry Initiative: Summary and Work Plans" dated September 1984). A total of $14 million/year for 1985 and 1986 was suggested, broken down as follows: $10 million/year from the Department of Energy (National Laboratories), $2.5 million/year from the Department of Commerce (National Bureau of Standards) and $1.5 million/year from the steel industry (AISI). The AISI funding would support 15 industry scientists who would work side-by-side with government scientists at the National Laboratories and at the Bureau of Standards. The importance of this close working relationship cannot be overemphasized. It could serve as a prototype for future joint government-industry "hands-on" collaborative efforts. In November the AISI Board of Directors approved participation at this funding level for two years, with half the funds to come from the AISI budget and half from the individual participating companies.

- In December Argonne National Laboratory had identified twelve scientists to work on their portion of the first year's work. Enthusiasm on the part of the government and industry scientists was high. The proposed research program was submitted by the Office of Science and Technology Policy to the Office of Management and Budget for approval in December with the strong endorsement of Argonne, NBS and AISI.

Unfortunately, because of budget reduction efforts at OMB, no funds were included for DOE or DOC for this program either for 1985 (supplemental) or 1986. In order for this program to stay alive we are advised that Congress will have to approve funding as a specific additional or reallocated item in the 1986 budget. We have been told that NBS will continue steel industry support at current levels, i.e., about $1 million/year, primarily for this research program, even if no additional funding is provided in the 1986 budget. We would ask that this Subcommittee consider authorizing DOE funding for this initiative in the FY 1986 budget. In so doing we want to emphasize that, as its popular title - the Keyworth Initiative - implies, the proposed research program received its main impetus through government sponsorship, obviously fully supported by the steel industry. With the strong encouragement of the Office of Science and Technology Policy, the National Laboratories, the Bureau of Standards and the steel industry are now all enthusiastic supporters of the program and a great deal of preliminary planning has been done. We believe the merits of this idea are self-evident and it could serve as a model for future industry-government collaborative efforts to improve the competitiveness of U.S. basic industries. This pioneering endeavor should not be allowed to die.

FEDERAL LABORATORY-STEEL INDUSTRY INITIATIVE

SUMMARY AND WORK PLANS

September 1984

Prepared for
American Iron and Steel Institute
at
Argonne National Laboratory

EXECUTIVE SUMMARY

Purpose

The purpose of this report is to describe what has been done to date on the federal laboratory/steel industry initiative and to seek industry support for it.

Background

The May 1983 report of the White House Science Council's Federal Laboratory Review Panel, known as the "Packard Report," strongly recommended increasing the collaboration of the federal laboratories* with universities and industry.

As members of the Presidential Committee on Industrial Competitiveness (PCIC), Dr. G. A. Keyworth, Science Advisor to the President, and Howard M. Love, Chairman of National Intergroup, identified the possibility that this recommendation could be related to the long-range problems of the domestic steel industry.

In a February 3, 1984, presentation to the PCIC, Mr. Love made the following suggestion:

> What I am proposing, then, is that steel firms come together to identify an agenda for R&D on leapfrog technologies, and then join with the National Labs to realize that agenda. Let me stress that this must be R&D on leapfrog technologies. If we fall into the rut of 'business-as-usual,' and merely agree on a modest agenda on R&D for incremental improvements, we will have failed. Let's envision a steel industry where we throw away the blast furnaces, throw away coke ovens, and develop entirely new ways of making a higher quality, higher yield product, at smaller scales, with greater flexibility and more automation.
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> Let me also stress that by seeking a technological solution, we are building upon our national strengths. We can't compete with the third world on the cost of labor or capital. The one thing we have in our favor is the best science and technology base in the world. Let's take advantage of the base; let's utilize it for the benefit of our basic industries.

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*There are 750 federal laboratories, all owned by the Federal Government. In FY 1985, they have a budget of $18 billion.

On February 8, 1984, members of the Committee on General Research joined Mr. Love and Dr. Keyworth for a meeting in the White House; and, shortly thereafter, joint exploratory studies between certain National Laboratories and steel industry scientists were underway. The nature of this joint effort was reviewed by Dr. Keyworth in his speech at the AISI General Meeting on May 24, 1984.

During the period May to September 1984, four joint task groups under the direction of a Joint Steering Committee made an intensive and well documented search for new approaches in steelmaking, casting, product development, and control engineering. The enthusiasm of the steel industry participants in these long-range analyses has been sustained by rapid, high-quality responses from the scientists at the Argonne and Oak Ridge National Laboratories and the National Bureau of Standards. There has also been all-around recognition that the steel industry is limited in its ability to commit its severely limited resources to long-term objectives.

Proposal

As a result of these studies, opportunities for long range and novel technological development have now been identified in two areas:

A. Direct Production of Liquid Steel from Iron Ore

The first objective is to develop for the mid-term (commercialization within about 15 years) an optimized process for the direct carbo-thermal reduction of iron ore to steel. The process sought would leapfrog existing technology by replacing the conventional coke oven and blast furnace and possibly also the subsequent steelmaking step. Coal is the preferred reductant in the process because of its inherent cost advantage over other fuels, and the process evaluation and development will emphasize the utilization of a wide range of domestic coals and iron ores as feedstocks. The ideal target process will result in a 50% reduction in capital costs and a 30% reduction in operating and maintenance costs as compared with present technology.

The second objective of this program is to investigate the feasibility of more innovative long-term and direct iron- and steelmaking technologies. The technologies to be explored include electromechanical refining, plasma processes, alternative chemical synthesis approaches, and biomining and biorefining. It is possible that one or more of the processes explored in these early feasibility studies may eventually become commercially viable in the long term (20 years or more).

B. Casting of Near Net Shape Solids

Because molds intrinsically have the potential to produce defects in cast metal, the main objective of this task will be to develop "mold-less" processes, especially for steel strip. The most promising approach will adapt electromagnetic containment currently in use for casting of aluminum. Further objectives are to (1) investigate methods for removal of nonmetallic inclusions to facilitate near-net-shape casting and (2) develop the solidification models, sensors, and the thermomechanical processing steps required to produce the requisite finished properties from the near-net-shape cast structure. This "model process" would achieve a superior product with minimal capital equipment, energy, and operating costs.

These opportunities are outlined in Sections A and B of this report, which also provide detailed estimates of the resources required in terms of federal and industry effort. It is clear that this is a long-range, speculative effort that is not designed, and is not likely, to produce near-term results.

Resources

Although this proposal will require relatively small resources from the industry in comparison to those being offered by the National Laboratories [ratio of 1:6], it will require that some companies make available top technical people to work in the Laboratories. This direct involvement is essential to ensure the relevance of the effort and the effective transfer of results to the industry.

Funding

In order to fairly share the industry cost of this major national research program, it is proposed that the required funds be raised by offering member companies the opportunity to participate at a cost proportionate to their respective domestic steel revenues in 1983. It is estimated that $1,400,000 should be provided for FY 1985 (10/1/84 to 9/30/85).

Timetable

The main effort during 1985 would be directed towards screening out the less promising candidates for development and scoping out specific project proposals to develop the most promising candidates. Towards the end of 1985, participating companies will be solicited for the level of support required to sustain the more focused program that would follow if the efforts in 1985 are successful. At this time, the second-year support requirement is expected to be about the same magnitude as in the first year.

TECHNICAL OVERVIEW

The science advisor to the President, Dr. G. A. Keyworth, has pointed out that the future of the U.S. steel industry may depend, in the long run, on its ability to achieve substantial increases in productivity through the application of "leapfrog technology." Moreover, he remarked that the development of such technology might be greatly facilitated if the research arm of the steel industry makes use of the broad capabilities of the national laboratories.

During the period May to September 1984, four task groups under the direction of a Joint Steering Committee comprised of steel industry, national laboratory, and government representatives made an intensive search for highly innovative approaches to iron- and steelmaking which, if developed, would give domestic steel firms a competitive advantage in the 1990s and beyond. Opportunities for novel- technology development were identified in two areas: (1) direct production of liquid steel from iron ore and (2) continuous electromagnetic casting of liquid steel to near-net-shape solids. After four meetings of the Steering Committee, some 15 meetings of individual task groups, and a number of visits by national laboratory representatives to steel firms, work plans were developed for R&D in these two areas. The work plans are included in Sections A and B of this report and are summarized below. The National Laboratories involved in this work will be Argonne and Oak Ridge, with the support of other laboratories and universities such as Purdue, National Bureau of Standards, and EG&G, Idaho.

The principal objective in the first work plan (Task A) is to develop an optimized process for the direct carbo-thermal reduction of iron ore to iron or directly to steel. The process sought would leapfrog existing technology by replacing the conventional coke oven and blast furnace and possibly also the subsequent steelmaking step. Coal is the preferred reductant in the process because of its inherent cost advantage over other fuels, and the process evaluation and development will emphasize the utilization of a wide range of domestic coals and iron ores as feedstocks. This effort to develop alternative iron- and steelmaking technologies builds directly upon the results and conclusions of the General Research Committee of the American Iron and Steel Institute (AISI), which recently completed a comprehensive review of the state of the art in this field. The time frame for this task is commercialization within the "mid-term," about 15 years.

The effort to develop this direct process will include the following phases: identification of a small number (five or less) of promising candidate processes using design analysis models, detailed analysis of the candidates under turndown (i.e., operation at below-full capacity) and nonsteady-state conditions, identification of the optimum overall process for subsequent bench-scale development, and the eventual design and construction of a pilot plant facility. The ideal direct process should result in about 50% reduction in capital costs and a 30% reduction in operating and maintenance costs, as compared with present technology.

A subordinate objective in the area of direct processing is to find solutions to the generic problems that have prevented or impeded commercial implementation of direct processes already in existence or under development. Two such problems are (1) excessive degradation experienced by refractories in contact with high-FeO slags at temperatures of 1600°C and (2) difficulty in eliminating entrained particulate and gaseous sulfur at temperatures of 800-1000°C. The latter problem occurs in candidate processes employing a two-stage configuration, with the reducing gas generated in the lower stage used to pre-reduce iron ore in the upper stage.

Another subordinate objective is to determine the feasibility of even more innovative direct iron- and steelmaking technologies such as electrochemical refining, plasma processes, biomining and biorefining, and refining and smelting with iron-based solvents. It is hoped that one or more of the processes explored will become commercially viable in the long term (20 years or more).

The lead laboratory for this project will be Argonne, which has extensive capabilities in development and application of systems analysis codes to a variety of technologies, including magnetohydrodynamics, combined-cycle-coal gasification, and nuclear power systems. Argonne also has technical expertise in such areas as fluidized-bed combustion, slag-refractory interactions, dirty gas cleanup, and complex chemical process systems.

The primary objective in the second work plan (Task B) is to develop an electromagnetic process for the continuous casting of near net shapes (large aspect ratios) requiring a minimum of additional thermal-mechanical processing; Argonne is the designated lead laboratory for this effort. Confidence in prospects for development of electromagnetic-based steel casting techniques is buoyed by the success achieved by the aluminum industry, which currently uses an electromagnetically assisted process to cast aluminum in a variety of shapes and sizes. This project is particularly attractive because of Argonne's extensive experience in the design, construction, and testing of state-of-the-art magnets and magnetic devices, including superconducting magnets; staff members are also skilled in the areas of electromagnetics, metallurgy, and the engineering of complex electromechanical systems.

This effort will begin with a nine-month engineering/economic feasibility study assessing the applicability of electromagnetic technology to the continuous casting of various grades of steel (Subtask 1). Subtask 2 will start 2-3 months after the initiation of Subtask 1 and will include the design and construction of magnets and proof-of-concept experimentation in support of the feasibility study findings. Subtask 3 will include the design, construction, and operation of a laboratory-scale electromagnetic test facility for the continuous casting of steel. If successful in verifying process feasibility, this facility will be followed in FY 1987 or 1988 by the initiation of a pilot-plant program to demonstrate scale-up reliability and economics. The pilot plant would be operated as a user facility available to all domestic steel companies. The electromagnetic continuous casting process is expected to achieve a superior product with minimal capital equipment, energy, and operating cost.

Support studies necessary for the development of the electromagnetic casting process will be an integral part of the R&D project. These studies will be directed toward (1) the development and verification of predictive models for the solidification/segregation process and for thermal-mechanical processing and (2) identification and development (as needed) of sensors for on-line monitoring of key process variables, including the nonmetallic inclusion content of the molten steel and the position of the liquid/solid interface. In addition, the support studies will include investigation of potential methods for the removal of nonmetallic inclusions in steel melts. Filtration of the melt and magnetic separation have been identified as two possible methods for removal of these inclusions.

Another study in this area will address the development of a scientific basis for the use of thermal-mechanical processing for controlling the properties of steel and also will seek to eliminate the hot-rolling mill during the processing of near-net-size casting to final product. In conventional steelmaking, large ingots are reduced in thickness by a series of hot deformation steps to a point where they can be fabricated to a desired form; property variations in a product line are often achieved by changes in chemical composition. With the new technology that will result from this effort, it should be possible to obtain extensive changes in properties within a single composition through control of the processing sequence. Oak Ridge will play a major role in this thermomechanical-processing project because of its experience in the areas of metal casting and processing, study of relationships between material microstructure and properties, and development of new alloys. Oak Ridge has the facilities to conduct the needed processing and the latest analytical tools for microstructure evaluation.

Initially, one or more flexible processing line simulators will be built to determine how various combinations of deformation and annealing treatments affect microstructure and properties in steels. Later, an experimental processing line will be built to study microstructure and properties on a large scale and in a more realistic manner. Successful completion of this study will simplify the thermal-mechanical processing of steel and relieve inventory requirements.

In conclusion, it must be emphasized that this initiative is quite limited in scope relative to the overall research needs of the steel industry and represents only those technological areas where efficient use can be made by the steel industry of the wide-ranging expertise in the national laboratories. Their selection was based on three criteria:

1. Projects which, if successful, will lead to significant mid- and long-term improvements in the competitive position of the U.S. steel industry.
2. Projects for which the federal laboratories, in particular Argonne and Oak Ridge, have a special, if not unique, combination of professional capabilities, facilities, and ideas.

3. Projects for which the aggregate funding requirements are consistent with federal funds anticipated over the next five years, assuming substantial incremental manpower from the steel industry.

Preliminary estimates indicate that this long-term research initiative will be funded by the federal government at a level of $10 million per year, with additional contributions by the steel industry in the form of staff time and facilities amounting to 20% of the governmental funding.

SECTION A

WORK PLAN FOR PROPOSED RESEARCH ON DOMESTIC RAW MATERIALS TO LIQUID STEEL

INTRODUCTION

The present program has been developed in response to a call issued by Presidential Science Advisor Dr. G. A. Keyworth that the federal laboratories apply their scientific and technical expertise to the development of advanced technology for improved productivity in the nation's basic industries. The domestic steel industry was identified as an appropriate opportunity for the development of such technology. In a series of meetings among steel industry, federal laboratory, and government representatives, four broad areas of technological need were identified, namely: (1) domestic raw materials to liquid steel, (2) liquid steel to near net shape solid, (3) universal and new grades of steel, and (4) automated processing technology. The present program addresses the first of these four areas.

Since the turn of the century, domestic steelmaking has been dominated by the coke oven/blast furnace/open hearth furnace (or, more recently, basic oxygen furnace) technology. The vast experience gained with this technology over the years has resulted in the development of a relatively sophisticated and efficient integrated process. However, ever larger facilities have been required to obtain increased throughput and improved productivity, and the capital and operating costs associated with these large facilities have imposed a considerable burden on the domestic industry. In addition, such large facilities often do not perform well when operated at reduced capacity, as at times of reduced product demand.

For these and other reasons, numerous attempts have been made to develop alternative direct iron- and steelmaking technologies that replace or bypass one or more of the conventional process steps. While a number of these alternative direct technologies have reached the pilot plant stage and (outside the U.S.) even limited commercial development, none has proven to be both technically and economically viable for the domestic industry. However, continuing progress has been made in direct iron- and steelmaking as well as in such related areas as plasma physics and coal gasification. In addition, the economics of steelmaking continue to change. These factors have resulted in renewed interest in direct processes, and the General Research Committee of the American Iron and Steel Institute (AISI) has recently completed a comprehensive review of the state of the art in this field. Approximately 12 direct reduction technologies have been identified in this review as offering significant technical and economic promise, and major generic problem areas associated with these technologies have been identified. The program described here builds directly upon the results and conclusions of the AISI study.

TECHNICAL OBJECTIVES

The principal technical objective of the present program as detailed in Task I is to develop for the mid-term (commercialization within about 15 yrs) an optimized process for the direct carbo-thermal reduction of iron ore to iron or, alternatively, directly to steel. The process sought would leapfrog existing technology by replacing the conventional coke oven and blast furnace and possibly also the subsequent steelmaking step. Coal is the preferred reductant in the process because of its inherent cost advantage over other fuels, and the process evaluation and development will emphasize the utilization of a wide range of domestic coals and iron ores as feedstocks. The ideal direct process will result in a 50% reduction in capital costs and a 30% reduction in operating and maintenance costs as compared with present technology.

A subordinate objective of the present program is to develop solutions to generic problem areas that prevent or impede the commercial implementation of candidate direct processes for the mid-term. One such generic problem area is the excessive penetration and dissolution experienced by refractories in contact with the high-FeO slags common to a number of proposed direct processes. In fact, slag containment represents the principal unsolved technical problem for several otherwise attractive processes. Another generic problem area to be considered under this program is that of hot dirty gas cleanup. A number of candidate processes employ a two-stage configuration, with the reducing gas generated in lower stage of the process used to prereduce iron ore in the upper stage. This reducing gas must first be cleaned of entrained particulate and gaseous sulfur (typically as H_2S) while at temperatures of the order of 1500 to 1800°F (800 to 1000°C).

A second subordinate objective of this program is to investigate the feasibility of more innovative long-term direct iron- and steelmaking technologies. The technologies to be explored include electrochemical refining, plasma processes, alternative chemical synthesis approaches, and biomining and biorefining. It is hoped that one or more of the processes explored in these early feasibility studies may eventually become commercially viable in the long term (20 yrs or more).

DESCRIPTION OF PROPOSED WORK THROUGH FY 1985

TASK I. DEVELOPMENT OF MID-TERM CARBO-THERMAL DIRECT PROCESSES

Task I is divided into four subtasks through the end of FY 1985, namely: (1) Design Analysis Simulation and Optimization Studies; (2) Simulation of Process Turndown; (3) Dynamic Simulation; and (4) Experimental Studies on Critical Unit Process Elements. The first of these subtasks is a design analysis modeling study that will identify a limited number (five or less) of candidate overall processes having the greatest potential for success. The turndown and dynamic behaviors of these processes will then be analyzed under subtasks (2) and (3), and the specific unit processes comprising the optimum overall process will be identified for subsequent development. It should be noted that the optimum overall process selected may well be a hybrid system made up of existing or modified unit processes from a number of candidate direct technologies. A schedule of activities and milestones is shown in Fig. 1. This schedule assumes timely funding at the levels indicated.

Activities under each of the four subtasks comprising Task I are described below.

1. Design Analysis Simulation and Optimization

The work to be conducted under this subtask will be planned and coordinated by Advisory Group A, made up of members from the federal laboratories, the steel industry, and universities. The modeling and evaluation of candidate processes will be carried out according to the following activities:

a. Review and Acquisition of Existing Models and Data

Existing industry-developed models of major iron- and steelmaking unit processes will be reviewed by a working group made up of the actual project team assembled to carry out this subtask plus selected members from the larger Advisory Group A. Those models judged applicable to the present study will be collected. Available documentation for these models will also be gathered, including assumptions and approximations made, numerical procedures and algorithms employed, and identifications of variables. In addition, the input data necessary to run these models will be collected. These data include values for selected thermodynamic and physical properties, reaction kinetics information, heat transfer characteristics, and mass and energy balances. Because economic considerations comprise an important part of the present evaluations, available information on capital and operating costs associated with the facilities required to carry out the various processes will also be gathered.

It should be noted that the existing steel industry models and data are critical to the present effort, and their timely acquisition by the working group is essential in order for this simulation and optimization study to achieve its stated objectives.

b. Critical Evaluation of Existing Models, Construction of a Generalized Systems Simulation and Optimization Code (SSOC), and Review of Program Status

The unit process models and data selected for use in this study will be critically evaluated by the project team with respect to their accuracy and compatibility, and, where necessary, they will be reformatted or rewritten. Entirely new models for specific process steps will be developed as needed. These existing and newly created models will then be incorporated into a generalized systems simulation and optimization code (SSOC) that can be used to evaluate the candidate direct reduction and direct steelmaking processes. This SSOC will be a proprietary version of an existing Argonne systems analysis code, as it will contain proprietary information supplied by the steel industry participants.

Upon completion of this activity, approximately six weeks after the initiation of the simulation and optimization study, the status and projected activities of the modeling effort will be reviewed by Advisory Group A.

c. Systems Simulation and Optimization Code Verification

The SSOC created as described under Activity b will be verified by applying it to well-characterized iron- and steelmaking systems for which heat and mass balances can be reliably related to capital and operating costs. The code will be further verified by applying it to processes for which only experimental data are available. The system and processes selected for verification will be chosen by the steel industry representatives on the working group. As part of the verification procedure, corrections and modifications will be undertaken until agreement with established models and experimental data is satisfactory.

d. Simulation and Optimization of New Systems

After verification, the SSOC will be applied to the analysis of the candidate direct reduction and direct steelmaking processes in order to compare their relative technical merits and economic potential. Also to be highlighted are the most important parameters affecting performance on economic viability. The priority for determining which systems to study will be based primarily on the suggestions from the industrial representatives. It should be noted that for this initial study, simulations will focus only on heat and mass balance calculations. Where required, all performance information will be selected on the most optimistic basis, hence, any systems which fail to be attractive need not be considered further unless changes in the selection process or economic data arise.

e. Initial Selection of Processes for Further Evaluation

Based upon the results of this initial optimization and analysis study, a limited number (five or less) of overall processes will be selected for follow-on evaluations of their turndown and dynamic characteristics. The critical judgments and assessments of the Advisory Group members will play a significant role in this initial selection process.

2. Simulation of Process Turndown

Because industrial iron and steel production facilities do not always operate at full capacity, their performance and economics under turned down conditions are important considerations. Therefore, the turndown characteristics of selected candidate direct processes will be evaluated where practical in this subtask using mathematical modeling and simulation techniques. Thus, work will again be coordinated by Advisory Group A, and the technical approach and methodology will be similar. The following activities will be performed:

a. Evaluation of Turndown in Industry Supplied Models

b. Construction of Turndown Models for Overall System

c. Validation of Turndown Models

d. Evaluation of Selected Processes

e. Evaluation of Selected Systems

f. Selection of Process for Further Development

Milestone f comprises a major critical event in the progress of the present program, since subsequent experimental research activities under Task I will focus largely on the development and demonstration of the overall direct process identified under this milestone. As stated previously, the process selected may well consist of existing or modified unit processes from a number of candidate direct technologies. The critical judgments and assessments of the Advisory Group A members, based upon the results of the various simulation studies conducted under Task I, will again play a major role in the selection process.

3. Dynamic Simulation

This mathematical simulation and modeling study will evaluate the performance of selected direct processes under nonsteady-state conditions, and, in particular, their control stability and response to perturbations and process upsets. The work will again be coordinated by Advisory Group A, and the following activities will be carried out through the end of FY 1985:

a. Evaluation of Dynamic Models Supplied by Industry

b. Construction of Dynamic Models not Supplied by Industry

c. Simulation of Key Dynamic Processes

Follow-on work on the simulation of overall systems will be performed in FY 1986. The mathematical modeling of the dynamic response of a complex process is often a very difficult task, and where the models developed are not adequate to properly assess the processes under consideration, critical engineering judgment will be used.

4. Experimental Studies on Critical Unit Process Elements

In the process of planning and coordinating the modeling and simulation work under subtasks 1, 2, and 3, it is anticipated that Advisory Group A will identify specific unit processes having obvious technical and economic advantages, but which are in need of further research and development. Possible examples include particle sticking in fluidized-bed direct reduction or the reaction kinetics and particle size requirements for any of a number of unit processes. Experimental work on the critical unit process elements identified by Advisory Group A will be conducted under this subtask. Because the findings of the Advisory Group cannot be predicted in advance, no detailed activities under this subtask can be outlined here.

TASK II. EXPERIMENTAL STUDIES IN GENERIC PROBLEM AREAS

In addition to the process-specific R&D needs to be identified under subtask 4 of Task II, certain technical problem areas common to a number of candidate direct processes have already been identified. These generic problems, which in some cases are the principal barrier to the further development of these processes, are treated in Task II. Thus, while Task I focuses on the identification and subsequent development of a single optimum direct process, Task II provides technical support to a broad range of direct iron- and steelmaking technologies.

Two subtasks are to be carried out under Task II, namely (1) High-temperature Process Containment, and (2) Hot Dirty Gas Cleanup. These subtasks are described below.

1. High-temperature Process Containment

A number of developmental direct iron- and steelmaking processes require the containment of aggressive liquid and gas phases at high temperature. These aggressive phases include high-FeO slags and iron melts as well as highly reducing sulfur-bearing multicomponent gas mixtures. Temperatures are typically of the order of 1600 to 1680°C (2900 to 3050°F), but in some direct steelmaking processes they may locally reach 2200°C (4000°F) or higher. The refractory materials commonly used in steelmaking generally experience excessive penetration, dissolution, and general degradation in these environments, thereby frustrating the further development of these processes. The goal of this subtask is to develop satisfactory means of high-temperature process containment for the environments encountered in proposed direct processes. Possible approaches to the containment problem include the development of improved refractory materials, modifications to process configurations to ameliorate the conditions present at the exposed surfaces, and the exploration of novel non-contacting containment schemes such as electromagnetic confinement.

The following activities are planned through the end of FY 1985:

a. Definition of Process Requirements and Development of Experimental Program

The range of operating environments and associated containment requirements for a spectrum of direct process will be defined in detail through a workshop or series of workshops involving steel industry, federal laboratory, university, and other participants. These workshops will also establish the present state of the art in refractories and alternative approaches to containment. A comprehensive experimental program will be developed based upon the determinations resulting from these workshops.

b. Experimental Studies on High-temperature Process Containment

The experimental program developed as described above will be implemented early in FY 1985. It is anticipated that this experimental program will focus on refractories evaluation and development for mid-term applications. Candidate refractories will be evaluated both in prototypic service environments as well as in model slags and melts having known thermodynamics. These studies will emphasize the microstructural, chemical, and mechanistic aspects of refractories degradation, and will include, as appropriate, electron microprobe analyses, mineralogical characterizations, kinetics determinations, and thermodynamic modeling studies. Developmental refractory materials and innovative fabrication techniques such as combustion synthesis will be explored.

In addition to refractories studies, the experimental program is anticipated to include work on approaches to ameliorating the hostile conditions present at containment walls, as by water cooling or modifying the slag chemistries. Long-term containment schemes such as electromagnetic containment, if found to be of interest under activity (a) above, will be investigated under Task III.

2. Hot Dirty Gas Cleanup

A number of candidate processes employ a two-stage configuration in which reducing gas generated in the lower stage of the process, typically by the gasification of coal, is used to pre-reduce iron ore in the upper stage. This reducing gas must first be cleaned of entrained particulate and gaseous sulfur (typically as H_2S) while at temperatures of the order of 1500 to 1800°F (800 to 1000°C).

The requirements on sulfur content in the reducing gas mixture can be estimated by considering a direct reduction process operating at 900°C (1650°F) in which it is desired to keep the sulfur level in the reduced iron below its maximum solubility of 0.02 wt %. This requires that the S_2 partial pressure in the reducing gas be below that which is in equilibrium with FeS at this temperature, or about 10^{-8} atm. The necessary H_2/H_2S ratio in the gas must then exceed ~300. For a reducing gas mixture containing 30 vol % H_2, the H_2S level must be below about 0.1 vol %. By comparison, the H_2S level in the raw gas from a typical gasifier utilizing high-sulfur coal is of the order of 0.5 to 1.0 vol %.

The two activities planned under his subtask through the end of FY 1985 are as follows:

a. Literature Review and Definition of Process Needs

The considerable literature in the area of hot dirty gas cleanup will be reviewed, and the requirements and constraints associated with the application of this technology to direct iron- and steelmaking will be defined.

b. Development and Initiation of Follow-on Research Program

A research program on hot dirty gas cleanup for direct processes will be developed based upon the results and conclusions from activity (a). Laboratory experiments on systems for both H_2S and particulate removal will be initiated.

TASK III. EXPLORATORY STUDIES ON INNOVATIVE LONG-TERM CONCEPTS

The research outlined in the first two tasks of this proposal deals with the development and implementation of direct process technology in the mid-term, i.e., within the next 15 yrs or so. In addition to this technology, however, a number of more innovative, long-term direct iron- and steelmaking concepts have been advanced. Initial exploratory studies on several such concepts are included under Task III.

1. Electrochemical Refining

Electrochemical methods of refining steel provide the possibility of well-controlled methods for removing impurities. For example, sulfur removal could be performed in a configuration in which the metal pool is the cathode overlain by a slag electrolyte into which an anode is immersed. The electrochemical system can be readily designed to act as a variable source of electrical heat so as to keep temperatures at a desirable level and to inductively stir the molten metal and slag phases for rapid kinetics. Because of cost and design limitations, electrochemical methods can be used to remove only small amounts (i.e., <5%) of impurities. However, they offer one the possibility of precise and rapid compositional control. In addition, research on these methods could, as a by-product, lead to real time sensors for some impurities in a compatible steelmaking system. It is likely that electrochemical methods would be most valuable in a continuous steelmaking process. Research will be conducted to determine the impurities which can be effectively removed electrochemically, the types of electrolytes which can be used and the methods for incorporating such techniques into current and future steelmaking systems inexpensively.

The activities to be carried out through the end of FY 1985 are as follows:

a. A literature survey and an evaluation of the possible methods and of the impurities which can be effectively removed by electrochemical techniques.

b. Electrochemical measurements of kinetic and thermodynamic factors as well as a determination of suitable electrolytes for the removal of a small number of significant impurities.

c. The adaptation of the results for designing electrochemical sensors of value in current or future steelmaking processes.

If the results are encouraging, future work would aim at refining the laboratory results and using them to design a small-scale test of the inherent capabilities of the concept for specific elements.

2. Iron Solvents for Refining or Smelting

Many metals are soluble in molten compounds of the same metal (e.g., Na in NaCl, Ca in $CaCl_2$, Ni in $NiCl_2$, Fe in FeS). The solubility of iron in a low melting multicomponent solution of iron compounds can be used to refine iron relatively rapidly by temperature cycling. For temperatures which are low enough, the crystallizing iron will tend to reject impurities down to very low levels. Such refining techniques could, for example, enable the use of unconventional ores such as pyrite. We propose an investigation of the solubilities of iron in melts which are potential solvents for iron and which might be useful for devising new steelmaking processes. Substances such as iron halides, iron oxides, iron sulfides, and their mixtures which have low liquidus temperatures (<1000°C) will be considered. We will also investigate the chemistry of other elements (phosphorus, manganese, nickel, etc.) in these mixtures in order to determine the achievable degree of separation of impurities and the modes of incorporating some desired alloying elements into the product metal. The most advanced concepts of solution thermodynamics will be combined with experimental measurements to achieve accurate descriptions of the chemical thermodynamic properties of the solvent melts and of impurity and alloying elements. Initial studies will focus on the liquidus (and solubility) properties of molten mixtures of iron salts with iron. Later work will focus on the chemical properties of solutes in selected melts and will be aimed at deducing equilibrium quotients of exchange reactions between iron and the constituents of the melt.

3. Assessment of Uses of Plasma

The use of plasma to reduce iron ore and produce liquid iron and steel has been frequently proposed and almost as frequently attempted. The most successful attempts to date have been the falling film concept of MacRae (Bethlehem Steel) and the PLASMARED process of SKF. In both cases, economic feasibility was not demonstrated, but technical feasibility was.

This assessment should provide additional information leading to possible alterations in present processing concepts, hopefully leading to a favorable economic evaluation. The particular area to be investigated is the relationship of extrinsic plasma variables (voltage, current, design parameters, etc.) to intrinsic parameters (temperature, composition, velocity of both plasma and particles) and the further relationship of these to product parameters (recovery, purity, etc.). The experimental diagnostic methods to be used are primarily optical requiring the ability to see within the active plasma regions. (The interrogative facilities and plasma generation facilities both exist at the INEL, substantially lowering the cost of the assessment.)

4. Assessment of Biological Support

Microbial processes have proved effective and economically feasible in industrial-scale processing of metal-bearing ores and treatment of various waste types. There has been little application of biological processes to the iron and steel industry. Among the areas which may benefit from biological processes are ore and coal beneficiation and waste water treatment.

Specific areas where biological coal or iron ore beneficiation may be practicable are:

1. Desulfurization. Sulfur in coal is pollutional and deleterious to product quality. Biological oxidation of mineral sulfide and organic sulfur to soluble forms is a method of reducing sulfur content.
2. Phosphorus. Phosphorus is found in many ore deposits and is deleterious to steel quality. Biological phosphorus removal has the potential to be an economical method for ore beneficiation.
3. Silicon. Silicon is abundant in iron ores and is problematic in steel production. Biological accumulation of silicon is readily observed in the microbial and macrobiotic world. Biological accumulation and solubilization may be utilized for improvement of raw ore quality.

Among these areas, Task Group A has determined that silicon removal is presently of greatest interest, with the other two beneficiation schemes being less important.

Amelioration and treatment of waste streams may be practiced biologically. Two specific areas where biological activity may benefit the iron and steel industry have been identified, but both are presently deemed outside the scope of the current initiative:

1. Treatment of acidic mine and coal pile drainages represent a large portion of mining monetary expenditure. Biological treatment of mine

drainage has been demonstrated in prototype scale to be a cost-effective alternative to physical-chemical treatment. Acidic drainages are of microbial origin. Abatement of drainage formation, practiced by inhibition of microbial activity, may prove effective in saving treatment costs.

2. Process waste treatment. Biological treatment may be a viable alternative to physical-chemical treatment of industry waste water. Biosorption of heavy metals, reduction of nutrient content, and oxidation of recalcitrant organic compounds are processes directly practiced biologically.

Limited feasibility studies and experiments will be conducted in FY 1985 particularly in the area of silicon removal from iron ore.

PROPOSED WORK BEYOND FY 1985

Detailed activities under the present program are difficult to project beyond FY 1985 at this time because, in large part, they depend upon results obtained in the first year of the program. In particular, the requirements of the overall process identified for further development and demonstration near the end of FY 1985 will greatly influence subsequent activities, especially under Task I. In general terms, research under the three tasks of this program beyond FY 1985 is expected to proceed as follows:

TASK I. DEVELOPMENT OF MID-TERM CARBO-THERMAL DIRECT PROCESSES

A comprehensive experimental program will be defined near the beginning of FY 1986 in support of the direct process technology identified by the simulation and optimization studies as the primary focus of this task. The specific elements of this program will be determined by the membership of Task Group A, based upon results obtained from the simulation and optimization studies. The program will initially emphasize R&D on critical aspects of key unit processes. As these specific problems are overcome, the experimental work under Task I will progress through the demonstration of unit processes, the assembly of these unit processes into a laboratory scale overall system, and the eventual design and construction of a pilot plant facility.

Modeling and simulation work on system dynamic behavior will continue into FY 1986. This work will define and analyze any control and stability problems associated with the direct iron- or steelmaking process selected for further development.

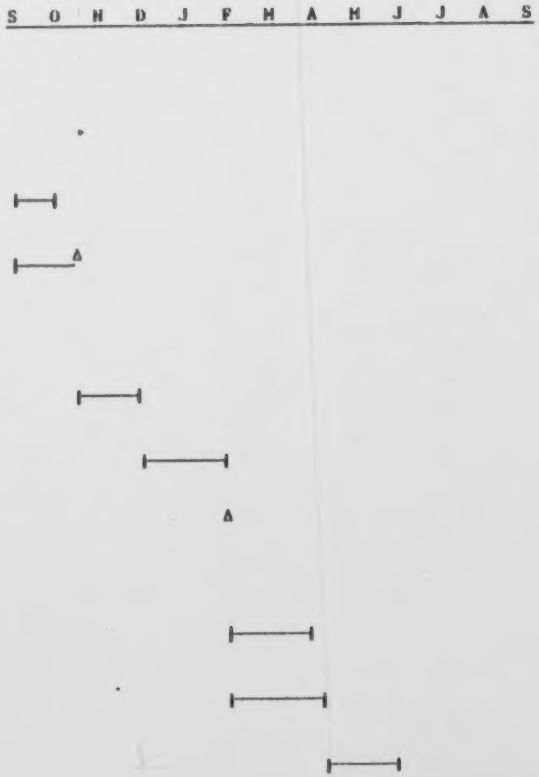
TASK II. EXPERIMENTAL STUDIES IN GENERIC PROBLEM AREAS

Both the high-temperature process containment and the hot dirty gas cleanup studies initiated in FY 1985 are multi-year subtasks that will continue at least through FY 1986. Results obtained from these studies will be applied to the carbo-thermal direct process being developed under Task I as appropriate, but Task II will remain a generic research effort in support of a broad range of mid-term direct iron- and steelmaking technologies. Research in other as-yet undefined generic problem areas may be initiated under Task II in subsequent years, although the total effort associated with this task is expected to remain substantially below that for Task I.

TASK III. EXPLORATORY STUDIES ON INNOVATIVE LONG-TERM CONCEPTS

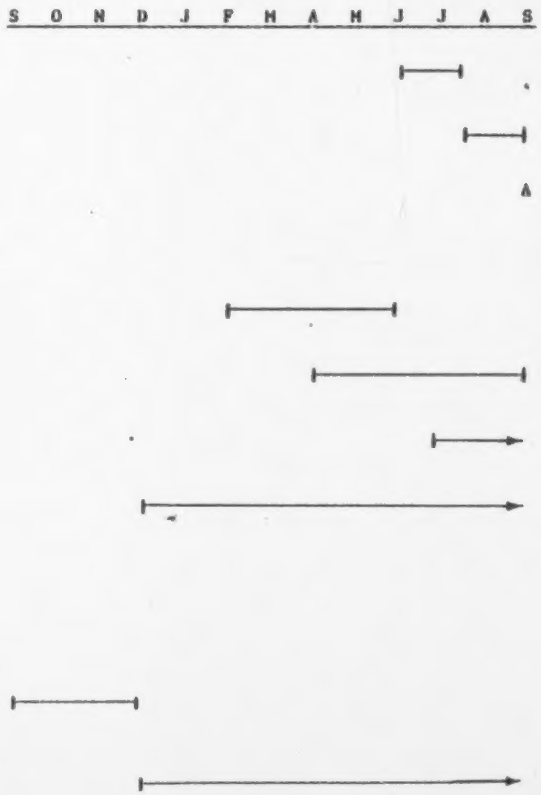
Feasibility studies on innovative long-term direct iron- and steelmaking concepts will continue beyond FY 1985 at an effort level approximating 20 to 25% of the total Task Group A program. The status of individual subtasks will be periodically reviewed and reassessed, and those exploratory concepts showing satisfactory technical and economic feasibility will be continued or expanded as appropriate. Innovative processes for which significant scientific or technological breakthroughs are achieved will be identified for further development under a separate task.

Fig. 1. Milestone Schedule through FY 1985.



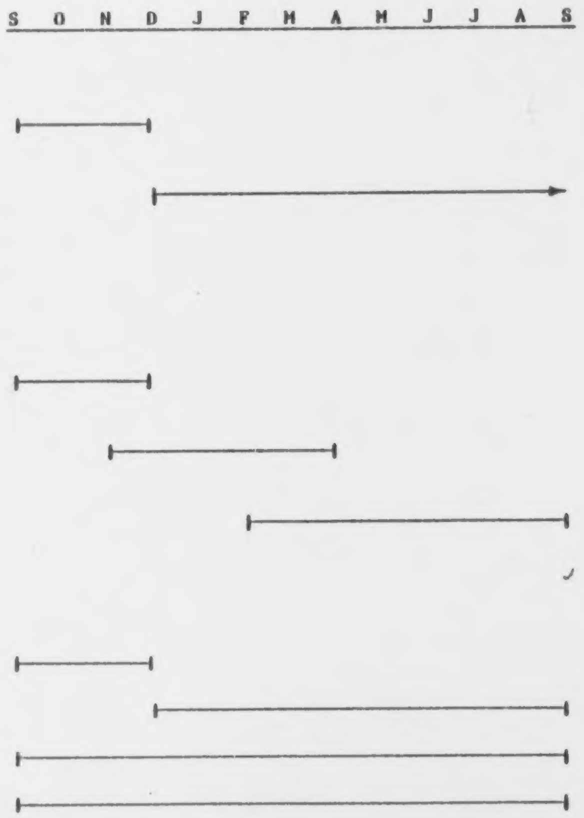
	Federal and Univ. Effort mm	Federal and Univ. Effort $K	Industry Effort mm
I. DEVELOPMENT OF MID-TERM CARBOTHERMAL DIRECT PROCESS			
1. Design Analysis Simulation and Optimization Studies	22	300	12
a. Review and acquisition of existing models and data			
b. Critical evaluation of existing models, construction of a generalized systems simulation and optimization code, and review (Δ) of program status			
c. Systems simulation and optimization code verification			
d. Simulation and optimization of new systems			
e. Initial selection of processes for further evaluation			
2. Simulation of Process Turndown	18	250	8
a. Evaluation of turndown in industry-supplied models			
b. Construction of turndown models for overall system			
c. Validation of turndown models			

Fig. 1. (Contd.)



	Federal and Univ. Effort mm	Federal and Univ. Effort $K	Industry Effort mm
d. Evaluation of selected processes			
e. Evaluation of selected systems			
f. Selection of process for further development			
3. Dynamic Simulation	18	250	6
a. Evaluation of dynamic models supplied by industry			
b. Construction of dynamic models not supplied by industry			
c. Simulation of key dynamic processes			
4. Experimental Studies on Critical Unit Process Elements	38	500	8
II. EXPERIMENTAL STUDIES IN GENERIC PROBLEM AREAS			
1. High-temperature Process Containment	32	450	6
a. Definition of process requirements and development of experimental program			
b. Experimental studies on high-temperature process containment			

Fig. 1. (Contd.)



	Federal and Univ. Effort mm	Federal and Univ. Effort $K	Industry Effort mm
2. Hot Dirty Gas Cleanup	22	300	4
a. Literature review and definition of process needs			
b. Development and initiation of follow-on research program			
III. EXPLORATORY STUDIES ON INNOVATIVE LONG-TERM CONCEPTS			
1. Electrochemical Refining	11	150	2
a. Literature survey and concept evaluation			
b. Plan and construct electrochemical experiments			
c. Perform electrochemical experiments			
2. Iron Solvents for Refining or Smelting	18	250	4
a. Literature survey			
b. Experimental investigations			
3. Assessment of Uses of Plasma	16	200	4
4. Assessment of Biological Support	8	100	2

SECTION B

WORK PLAN FOR PROPOSED RESEARCH ON
LIQUID STEEL TO NEAR NET SHAPE

RESEARCH PROJECT

TASK GROUP B: Liquid Steel to Near Net Shape

Project Title: Near Net Shape Casting

Objective: To develop an innovative process for the continuous casting of various grades of steel in large-aspect-ratio shapes such as steel strip. Further objectives are (1) to develop and verify predictive models for solidification and thermal-mechanical processing, (2) to develop and verify a scientific basis for the use of thermal-mechanical processing for controlling the properties of steel, (3) to identify sensors for on-line process monitoring and control, and (4) to investigate methods for removal of nonmetallic inclusions. This "model process" is expected to achieve a superior product with minimal capital equipment, energy, and operating costs.

Scope: Electromagnetic fields, alone or in combination with mechanical systems, appear to have potential for innovative application to the continuous casting of steel. The success achieved in this area by the aluminum industry provides confidence that electromagnetic techniques can be successfully developed for this purpose. The prime focus of this R&D project will be directed towards the electromagnetic continuous casting of steel in large-aspect-ratio shapes requiring a minimum of additional thermal-mechanical treatment. This process should also be applicable to the casting of other shapes such as tubes, squares, slabs, and "dogbones". Support studies necessary for the development of the electromagnetic casting process will be an integral part of this R&D project. The major tasks are listed below. The efforts in each Task are structured to yield information and results needed to provide program guidance and to maintain focus on the primary objective. This high degree of interaction between the four tasks is considered essential to attain the goal of this project.

Task I. Electromagnetic Technology for Casting Process

Although electromagnetic technologies have been applied to the casting of aluminum, the U.S. aluminum industry is presently using a batch rather than a continuous process. Further, the cast products are slabs and ingots rather than a thin strip or sheet of large aspect ratio. While the technology developed for casting aluminum is expected to be beneficial to this research project, it should be noted that the goal of this project surpasses what has been achieved thus far by the aluminum industry.

This task begins with a comprehensive feasibility study (Subtask 1.1), which will take approximately nine months and include an analysis of the current status of electromagnetic technology in casting metals and its applicability to steel. Subtask 1.2, which will commence shortly after the start of Subtask 1.1 (i.e., 2-3 months), will include the design and construction of magnets and proof-of-concept experimentation in support of the findings in the feasibility study. Subtask 1.3 will include the design, construction, and operation of a laboratory-scale test facility to demonstrate feasibility for electromagnetic continuous casting of steel. It is expected that these facilities, if they are successful in verifying process feasibility, will be followed (in FY 1987/1988) by the initiation of a pilot plant program (Subtask 1.4) to demonstrate scale-up reliability and economy.

Important parameters to be resolved in the proof-of-concept experimentation include (1) electromagnetic field configurations, strength, and constraints; (2) liquid steel handling system; (3) thermal-hydraulic constraints; (4) stability of liquid metal in magnetic field; and (5) diagnostic sensors and process control instruments. Support studies such as ladle metallurgy, tundish refining, inclusion control, heat/fluid transfer, and metallurgy of the cast/final product will be an integral part of this task. The results from Task 2 will have a direct bearing on the casting process and will provide guidance for Task 1.

Task II. Experimentally Verified Predictive Models for Solidification and Thermal-Mechanical Processing

Solidification - A well-focused program will be conducted to apply modern solidification theory and develop predictive computer models for heat flow/fluid flow (including electromagnetic stirring), solidification/segregation in cast structures, and rapid solidification of continuously cast strip/sheet of steel alloys. Promising models would be verified by careful experimentation on controlled laboratory-scale systems. Control models will be developed for the electromagnetic continous casting process based on the predictive models developed in this task. Studies will also be conducted to quantify the changes in cast microstructures as a function of composition, thermal gradients, and growth rate and/or cooling rate and establish the minimum range of cold and hot deformation (rolling) necessary to achieve acceptable properties (e.g., surface finish, microstructure, work hardening, strength).

Thermal-Mechanical Processing - A program will be conducted to develop a scientific basis for the use of thermal-mechanical processing for controlling the properties of steels and to experimentally determine the processing parameters necessary to transform the material coming from a continous large-aspect-ratio casting operation into a marketable product. It will provide experimental facilities for simulating or for duplicating on a laboratory scale complex sequences of thermal and mechanical processing steps. Other activities will be directed at development of an understanding of processing-microstructure-property relationships in model steels. The thrust of this work will be directed toward processing of thin cross section materials produced by the task on Electromagnetic Technology for Casting Process (Task I). It will also provide a basis for controlling the properties of steel through manipulation of processing variables, thereby reducing the large number of separate compositions that must be produced. The experimental facilities developed and maintained by this developed and maintained by this task will be operated in a user mode to enable individual steel companies to carry out alloy or processing development programs to develop steels to meet the needs of their customers. Steel industry employees will participate in most of the tasks described here.

In general, the efforts in this task are structured to be supportive of Task I and to provide guidance. Also, it is apparent that the results from this task will be applicable to other casting systems.

Task III. Sensors for On-Line Process Monitoring

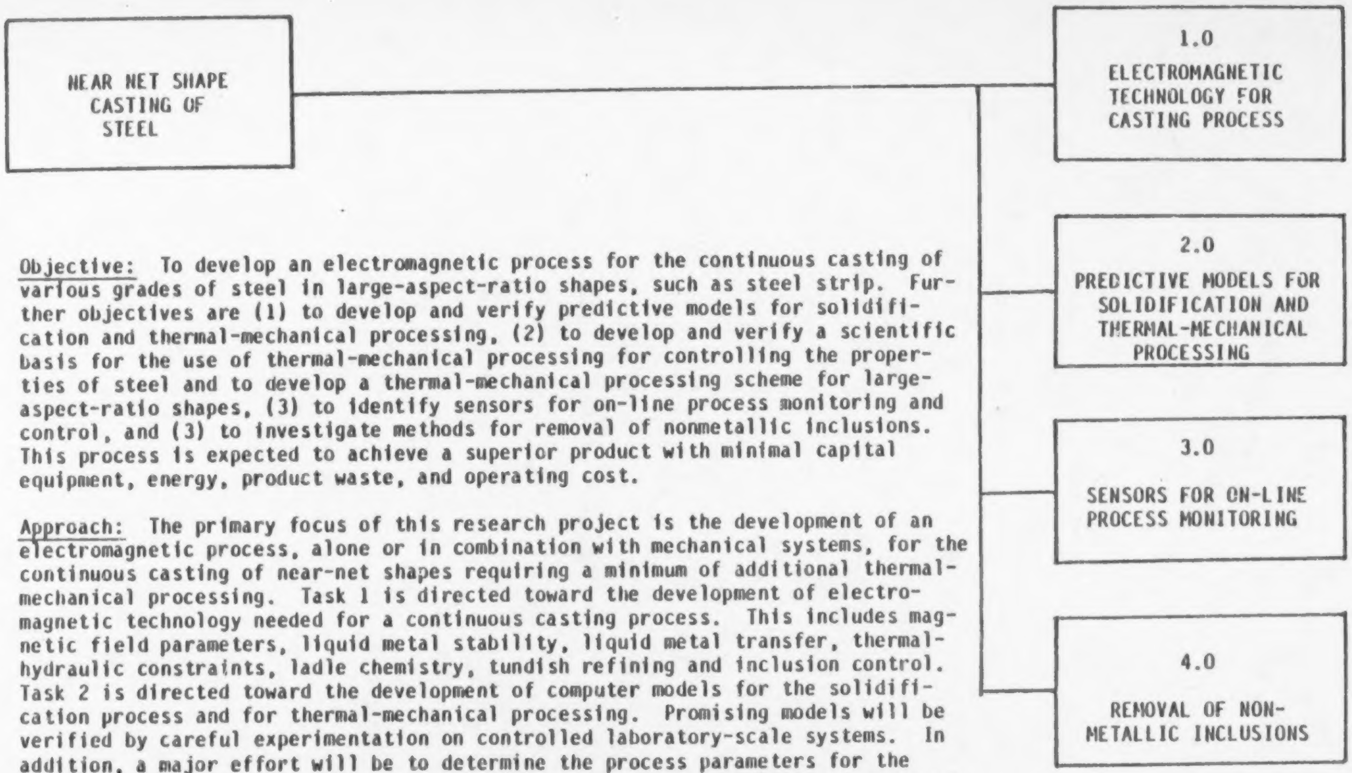
Automated processing of near-net-shapes cannot be carried out without on-line monitoring of key process variables and/or the evolution of microstructures and defects. a number of Steel Industry/Federal Laboratory Programs are already under way to develop four specific sensors identified by industry. Two additional sensors of particular importance to this "model process" were identified for development: (1) monitoring of inclusion content in liquid steel and (2) determination of solid/liquid interface position during casting. Also, efforts will be directed toward the identification and development of sensors needed for computer-based control of the electromagnetic continuous casting process.

Task IV. Investigation of Methods for the Removal of Nometallic Inclusions from Steel Melts

The presence of nonmetallic inclusions (oxides, sulfides, nitrides, etc.) in liquid steel feedstock for continuous near-net-shape casting processes has been identified as a key problem affecting product acceptability. Filtration of molten metal to remove certain inclusions has been demonstration as being commercially feasible in the aluminum industry, but the application to molten steel is much more difficult due to the higher temperatures, steeper thermal gradients, and greater hydrodynamic forces that occur in steelmaking. The emphasis of this task will be on the reduction of inclusion formation through control of the interaction of liquid steel with its environment (i.e., refractories and atmosphere) and the removal of inclusions through possibly physical filtration and/or magnetic separation. The development of sensors for the detection of inclusions will be a necessary part of this task. These efforts will be coordinated with those in Tasks I, II, and III.

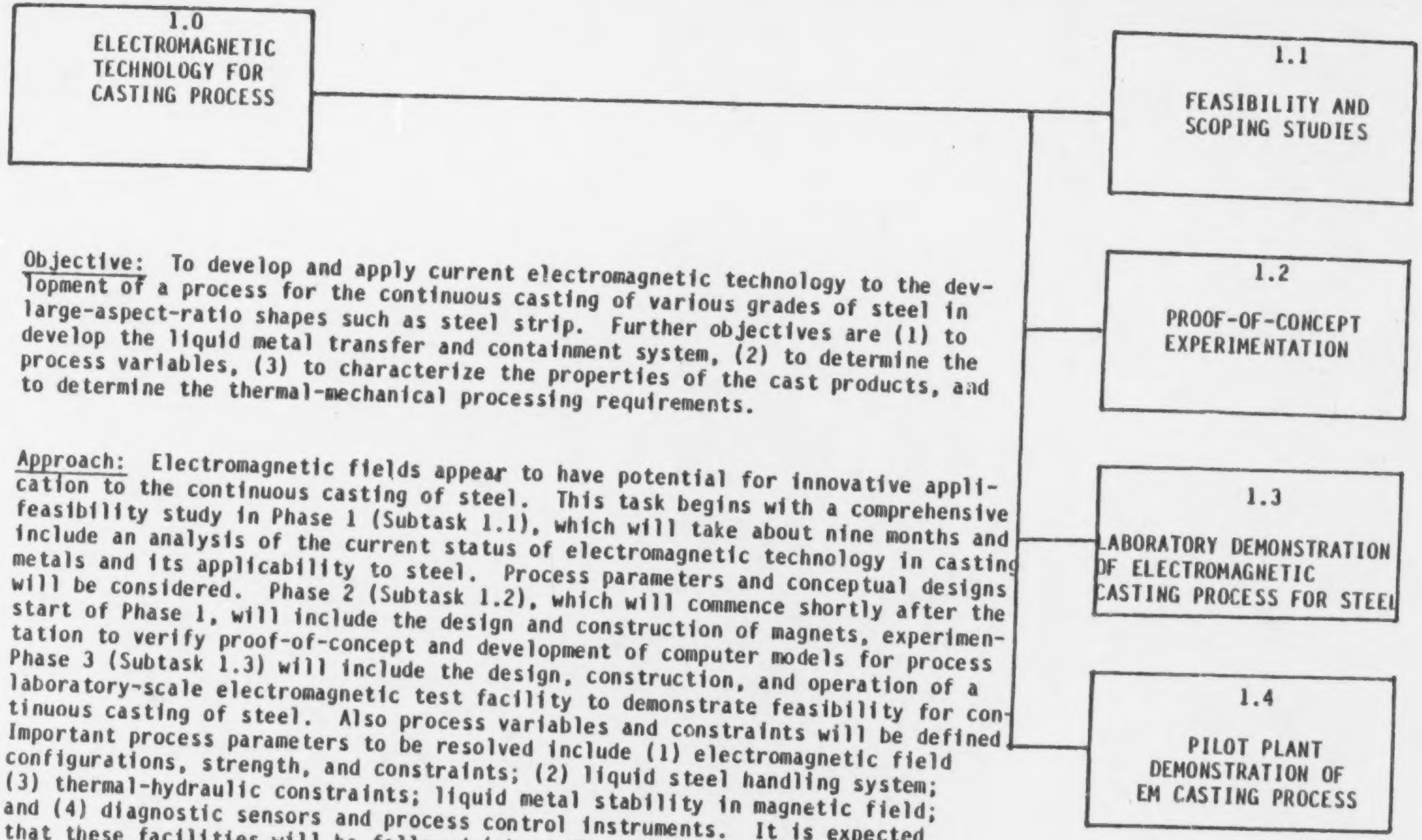
Program Schedule/Funding: A detailed Work Breakdown Structure (WBS) with estimated manpower requirements is presented in Table 1. The numbers above the activity lines represent the estimated manpower requirements in man months per quarter. The numbers in ( ) below the activity lines indicate additional manpower contingent on NBS receiving expected funding from the Department of Commerce. A summary of the WBS, manpower, and funding requirements is provided at the end of Table 1. The projected funding levels from the Department of Energy for FY 1985 and FY 1986 are $5.3 M and $8.3 M, respectively. The projected funding expected by the NBS from the Department of Commerce is $1.45 M and $1.92 M for FY 1985 and FY 1986, respectively. Also, additional manpower as industrial participants is expected to be provided by the steel industry at the level of nine man years for FY 1985 and 11 man years for FY 1986.

Deliverables: Periodic progress reports will be prepared on a schedule to be determined by Task Group B and the Steering Committee. Topical reports will be prepared at the conclusion of specific subtasks.


NEAR NET SHAPE CASTING OF STEEL
1.0
ELECTROMAGNETIC TECHNOLOGY FOR CASTING PROCESS
2.0
PREDICTIVE MODELS FOR SOLIDIFICATION AND THERMAL-MECHANICAL PROCESSING
3.0
SENSORS FOR ON-LINE PROCESS MONITORING
4.0
REMOVAL OF NON-METALLIC INCLUSIONS

Objective: To develop an electromagnetic process for the continuous casting of various grades of steel in large-aspect-ratio shapes, such as steel strip. Further objectives are (1) to develop and verify predictive models for solidification and thermal-mechanical processing, (2) to develop and verify a scientific basis for the use of thermal-mechanical processing for controlling the properties of steel and to develop a thermal-mechanical processing scheme for large-aspect-ratio shapes, (3) to identify sensors for on-line process monitoring and control, and (3) to investigate methods for removal of nonmetallic inclusions. This process is expected to achieve a superior product with minimal capital equipment, energy, product waste, and operating cost.

Approach: The primary focus of this research project is the development of an electromagnetic process, alone or in combination with mechanical systems, for the continuous casting of near-net shapes requiring a minimum of additional thermal-mechanical processing. Task 1 is directed toward the development of electromagnetic technology needed for a continuous casting process. This includes magnetic field parameters, liquid metal stability, liquid metal transfer, thermal-hydraulic constraints, ladle chemistry, tundish refining and inclusion control. Task 2 is directed toward the development of computer models for the solidification process and for thermal-mechanical processing. Promising models will be verified by careful experimentation on controlled laboratory-scale systems. In addition, a major effort will be to determine the process parameters for the direct processing of near-net-size castings to final products that meet customer requirements. Task 3 is directed toward the identification and development (as needed) of sensors for on-line monitoring of key process variables, such as inclusion content and liquid/solid interface position. Task 4 will investigate potential methods for the removal of non-metallic inclusions in steel melts. Filtration of the melt and open gradient magnetic separation have been identified as two possible methods for removal of nonmetallic inclusions.


1.0
ELECTROMAGNETIC
TECHNOLOGY FOR
CASTING PROCESS
1.1
FEASIBILITY AND
SCOPING STUDIES
1.2
PROOF-OF-CONCEPT
EXPERIMENTATION
1.3
LABORATORY DEMONSTRATION
OF ELECTROMAGNETIC
CASTING PROCESS FOR STEEL
1.4
PILOT PLANT
DEMONSTRATION OF
EM CASTING PROCESS

Objective: To develop and apply current electromagnetic technology to the development of a process for the continuous casting of various grades of steel in large-aspect-ratio shapes such as steel strip. Further objectives are (1) to develop the liquid metal transfer and containment system, (2) to determine the process variables, (3) to characterize the properties of the cast products, and to determine the thermal-mechanical processing requirements.

Approach: Electromagnetic fields appear to have potential for innovative application to the continuous casting of steel. This task begins with a comprehensive feasibility study in Phase 1 (Subtask 1.1), which will take about nine months and include an analysis of the current status of electromagnetic technology in casting metals and its applicability to steel. Process parameters and conceptual designs will be considered. Phase 2 (Subtask 1.2), which will commence shortly after the start of Phase 1, will include the design and construction of magnets, experimentation to verify proof-of-concept and development of computer models for process Phase 3 (Subtask 1.3) will include the design, construction, and operation of a laboratory-scale electromagnetic test facility to demonstrate feasibility for continuous casting of steel. Also process variables and constraints will be defined Important process parameters to be resolved include (1) electromagnetic field configurations, strength, and constraints; (2) liquid steel handling system; (3) thermal-hydraulic constraints; liquid metal stability in magnetic field; and (4) diagnostic sensors and process control instruments. It is expected that these facilities will be followed (about FY 1988) by the initiation of a pilot plant program (Subtask 1.4) to demonstrate scale-up reliability and economy.

1.1

FEASIBILITY AND SCOPING STUDIES

Objective: To examine current electromagnetic technology and its applicability for the continuous casting of various grades of steel, to determine the combination of parameters for which it is practical, and to identify the major problems that require more analytical and experimental studies.

Approach: The current status of electromagnetic casting technology will be reviewed and conceptual designs for the casting of large-aspect-ratio shapes will be prepared. The process parameters and interactions will be defined. Other properties to be analyzed include liquid metal stability in magnetic field, the thermal-hydraulic and heat transfer characteristics, and the properties of the liquid steel.

SUBTASKS:	FY 1985		FY 1986					
1.1.1 Review current status of electromagnetic continuous casting (EMCC) technology	9							
1.1.2 Perform conceptual designs for EMCC	6 6	6						
1.1.3 Define EMCC parameters, their ranges and interactions	6 6							
1.1.4 Analyze electromagnetic field and liquid metal stability	3	3						
1.1.5 Analyze the thermal-hydraulic and heat transfer characteristics	3	3						
1.1.6 Define required liquid metal properties for casting		3						
1.1.7 Perform preliminary process cost and benefit evaluations		3						
1.1.8 Report on recommendation for process development		2						
1.1.9 Prepare technology transfer plan		1						
MANPOWER, MAN MONTHS/MO	7 6	7						

1.2

PROOF-OF-CONCEPT EXPERIMENTATION

Objective: To experimentally determine the feasibility of using electromagnetic technology for the continuous casting of steel in large-aspect-ratio shapes and to identify the key process variables.

Approach: An experimental, bench-scale electromagnetic casting system will be designed and constructed. The initial experiments to determine the process variable will be conducted on high-density, low-melting point metals. Subsequent experiments will be conducted on steel. The cast products will be characterized for quality and preliminary computer models for the EMCC process will be developed and verified.

SUBTASKS:		FY 1985	FY 1986		
1.2.1	Prepare plans for experimentation	3			
1.2.2	Design and construct electromagnetic casting system*	12 18			
1.2.3	Determine experimentally the process variables for casting high-density, low-melting point metals	9			
1.2.4	Determine experimentally the process variables for EM casting of steel	6	12 9 12		
1.2.5	Characterize the EM cast products and compare with results from predictive models (Task 2.0)	6	6 6 6 9		
1.2.6	Develop and verify preliminary computer models for EMCC process	3 3 6	9 6		
1.2.7	Prepare report including recommendations for process development		3		
*Major equipment - $125K					
MANPOWER, MAN MONTHS/MO		6 7 9	9 8 6 3		

1.3

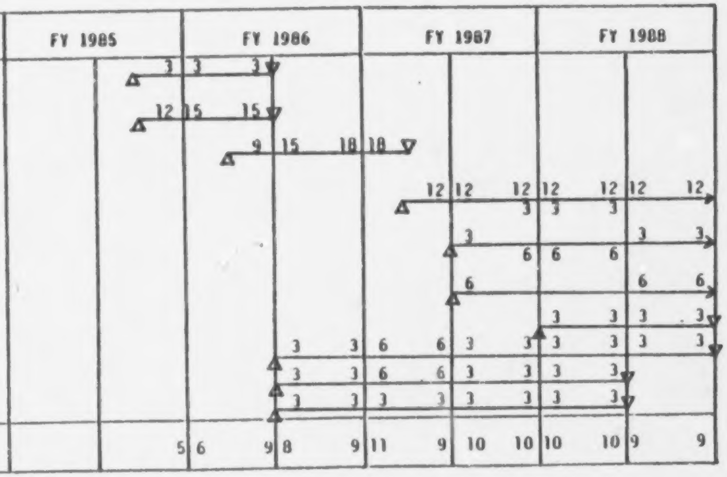
LABORATORY DEMONSTRATION OF ELECTROMAGNETIC CASTING PROCESS FOR STEEL

Objective: To demonstrate the technical feasibility for electromagnetic continuous casting of steel in large-aspect-ratio shapes requiring minimum thermal-mechanical processing and to determine the process control requirements.

Approach: A laboratory scale electromagnetic casting system with liquid metal feed, electromagnetic containment, cooling, and mechanical withdrawal system will be designed and constructed. Experiments will be conducted to determine the process variables, the thermal-mechanical processing requirements, and process control requirements. Also, the cast products will be evaluated for quality and controlled atmospheres for the casting systems will be investigated.

SUBTASKS:	
1.3.1	Prepare plans for laboratory scale-up experimentation
1.3.2	Design liquid metal feed, electromagnetic containment, cooling, and mechanical withdrawal system for EMCC lab facility
1.3.3	Construction of EMCC laboratory facility*
1.3.4	Determine experimentally the process variables for large-aspect-ratio shapes (Thru FY 1989)
1.3.5	Characterize the EM cast products (Thru FY 1989)
1.3.6	Determine thermal-mechanical processing requirements for commercial product (Thru FY 1989)
1.3.7	Investigate EM castability of other steel alloys and shapes
1.3.8	Investigate controlled atmospheres for casting systems
1.3.9	Determine process control requirements
1.3.10	Refine computer models for EMCC process

*Equipment - $2M. MANPOWER, MAN MONTHS/MO



1.4

PILOT PLANT DEMONSTRATION OF ELECTROMAGNETIC CASTING PROCESS

Objective: To demonstrate the technical feasibility of a full-scale electromagnetic continuous casting process for steel.

Approach: The design, cost and benefit analysis of a full-scale EMCC system will be upgraded. Based on the success of Subtask 1.3, a pilot plant will be designed and constructed to demonstrate the electromagnetic continuous casting of steel in large-aspect-ratio shapes. The electromagnetic and casting parameters will be determined and correlated to the cast and final products. The process will be optimized to achieve a superior product and minimal cost.

SUBTASKS:

1.4.1 Upgrade design, cost and benefit study of full-scale EMCC process

1.4.2 Prepare operational plan for pilot plant facility

1.4.3 Prepare preliminary design of pilot plant EMCC facility

1.4.4 Prepare final design and engineering for pilot plant EMCC facility

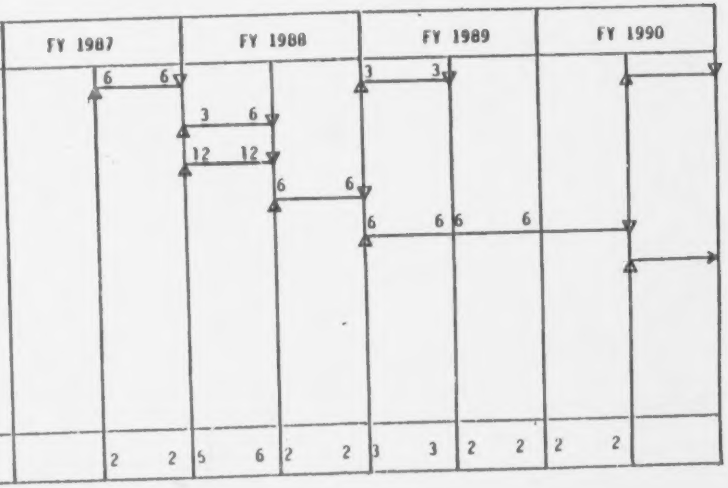
1.4.5 Construct EMCC pilot plant facility*

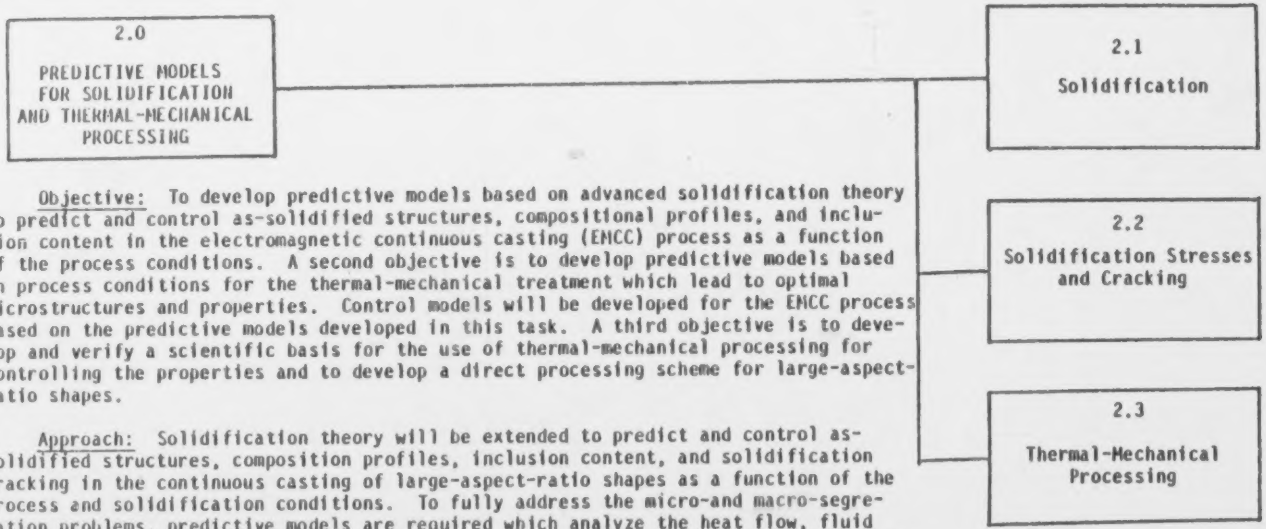
1.4.6 Operate pilot plant**

* Facility cost to be determined; first estimate is about $15M

** Period of operation to be determined

MANPOWER, MAN MONTHS/MO




2.0
PREDICTIVE MODELS FOR SOLIDIFICATION AND THERMAL-MECHANICAL PROCESSING
2.1
Solidification
2.2
Solidification Stresses and Cracking
2.3
Thermal-Mechanical Processing

Objective: To develop predictive models based on advanced solidification theory to predict and control as-solidified structures, compositional profiles, and inclusion content in the electromagnetic continuous casting (EMCC) process as a function of the process conditions. A second objective is to develop predictive models based on process conditions for the thermal-mechanical treatment which lead to optimal microstructures and properties. Control models will be developed for the EMCC process based on the predictive models developed in this task. A third objective is to develop and verify a scientific basis for the use of thermal-mechanical processing for controlling the properties and to develop a direct processing scheme for large-aspect-ratio shapes.

Approach: Solidification theory will be extended to predict and control as-solidified structures, composition profiles, inclusion content, and solidification cracking in the continuous casting of large-aspect-ratio shapes as a function of the process and solidification conditions. To fully address the micro-and macro-segregation problems, predictive models are required which analyze the heat flow, fluid flow, and segregation phenomena. These models must be extended beyond the regimes of the slower ingot casting process because of the higher solidification rates expected in this new process. These new models must be guides and verified by controlled laboratory-scale experiments. Predictive models will also be developed for relating the as-solidified structures to the mechanical properties of the final product as a function of the intermediate thermal-mechanical processing. Subtask 2.1 is directed toward modeling and verifying the solidification process, micro-and macro-segregation and process variables. The efforts in Subtask 2.2 will develop and verify models for solidification stresses and the effects of process variables on casting defects. Subtask 2.3 will develop models to predict mechanical properties as a function of cast structures and to predict response of cast structures to thermal-mechanical processing. Further, this effort will determine the optimum thermal-mechanical processing parameters for controlling the properties of large-aspect-ratio cast materials, develop methods to minimize scale formation and for scale removal, and develop an instrumented facility for the direct processing of near-net-size castings to final products. Also, the effects of EMCC process variables on structures and segregation will be determined. The results of this effort are expected to guide and focus the work in Task 1.0

2.1

SOLIDIFICATION

Objective: To develop and experimentally verify models of solidification and apply them to predict the effects of process variables on the microstructures of EMCC products.

Approach: A comprehensive review will be conducted of the current status of predictive modelling of solidification and extend theory to the EMCC process. Capabilities will be developed to predict the effect of process variables on solidification morphology and micro-and macro-segregation. The validity of these models will be experimentally verified.

SUBTASKS:		FY 1985		FY 1986		FY 1987		FY 1988	
2.1.1	Review current status of predictive modelling of solidification	6 6	6 6						
2.1.2	Develop and verify models of interface stability and composition path as a function of interface velocity	0 0 (3) (3)	3 3	3 3 (2) (2)	3 3 (2) (2)	3 3 (2) (2)	3 3 (2) (2)	3 3 (2) (2)	3 (2)
2.1.3	Develop and verify models for micro segregation and inclusions	0 0 (3) (3)	3 3	3 3 (2) (2)	3 3 (2) (2)	3 3 (2) (2)	3 3 (2) (2)	3 3 (2) (2)	3 (2)
2.1.4	Develop and verify models for heat and fluid flow and macro segregation	0 0 (3) (3)	3 3	3 3 (2) (2)	3 3 (2) (2)	3 3 (2) (2)	3 3 (2) (2)	3 3 (2) (2)	3 (2)
2.1.5	Model and verify the effects of EMCC process variables on structure and segregation							TBD	TBD
NOTE:	The numbers above the activity lines represent the estimated manpower requirements for the core program. The numbers in ( ) below the activity lines indicate additional manpower contingent on NBS receiving expected funding from the Department of Commerce.								
MANPOWER, MAN MONTHS/MO		2 2 (3) (3)	5 5	3 3 (2) (2)	3 3 (2) (2)	3 3 (2) (2)	3 3 (2) (2)	3 3 (2) (2)	3 3 (2) (2)

2.2

SOLIDIFICATION STRESSES AND CRACKING

Objective: To develop and experimentally verify predictive models for solidification stresses, hot tearing and cracking during the EMCC of steel in large-aspect-ratio shapes.

Approach: A comprehensive review will be conducted on recent research development, and models to predict solidification stresses will be developed. These models will be coupled with solidification theory to understand the role of process variables in the development of residual stresses, hot tearing and cracking. Processing scenarios to minimize or eliminate hot tearing will be developed.

SUBTASKS:	FY 1985				FY 1986				FY 1987				FY 1988			
2.2.1 Review current status	1.5	1.5	1.5	1.5												
2.2.2 Develop and verify predictive models for the evolution of solidification stresses	0 (1.5)	0 (1.5)	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2.2.3 Couple models for solidification stresses and segregation to predict casting defects	0 (1.5)	0 (1.5)	0 (3)	0 (3)	0 (4.5)	0 (4.5)	0 (4.5)	0 (4.5)	1.5 (3)	1.5 (3)	1.5 (3)	1.5 (1.5)	1.5 (1.5)	1.5 (1.5)	1.5 (1.5)	1.5 (1.5)
2.2.4 Determine the effects of EMCC process variables on casting defects*											1.5					
MANPOWER, MAN MONTHS/MO	.5 (1)	.5 (1)	1.5 (1)	1.5 (1)	1 (1.5)	1 (1.5)	1 (1.5)	1 (1.5)	1.5 (1)	1.5 (1)	1.5 (1)	2 (0.5)	2 (1.5)	2 (1.5)	2 (1.5)	2 (1.5)

*Manpower to be determined.

NOTE: The numbers above the activity lines represent the estimated manpower requirements for the core program. The numbers in ( ) below the activity lines indicate additional manpower contingent on NBS receiving expected funding from the Department of Commerce.

2.3

THERMAL-MECHANICAL PROCESSING

Objective: To develop new models to predict the role of thermal-mechanical treatments on the microstructure-property relations of EMCC materials and other near-net-size materials and to develop thermal-mechanical techniques for the direct processing of these materials to final products that meet customer requirements.

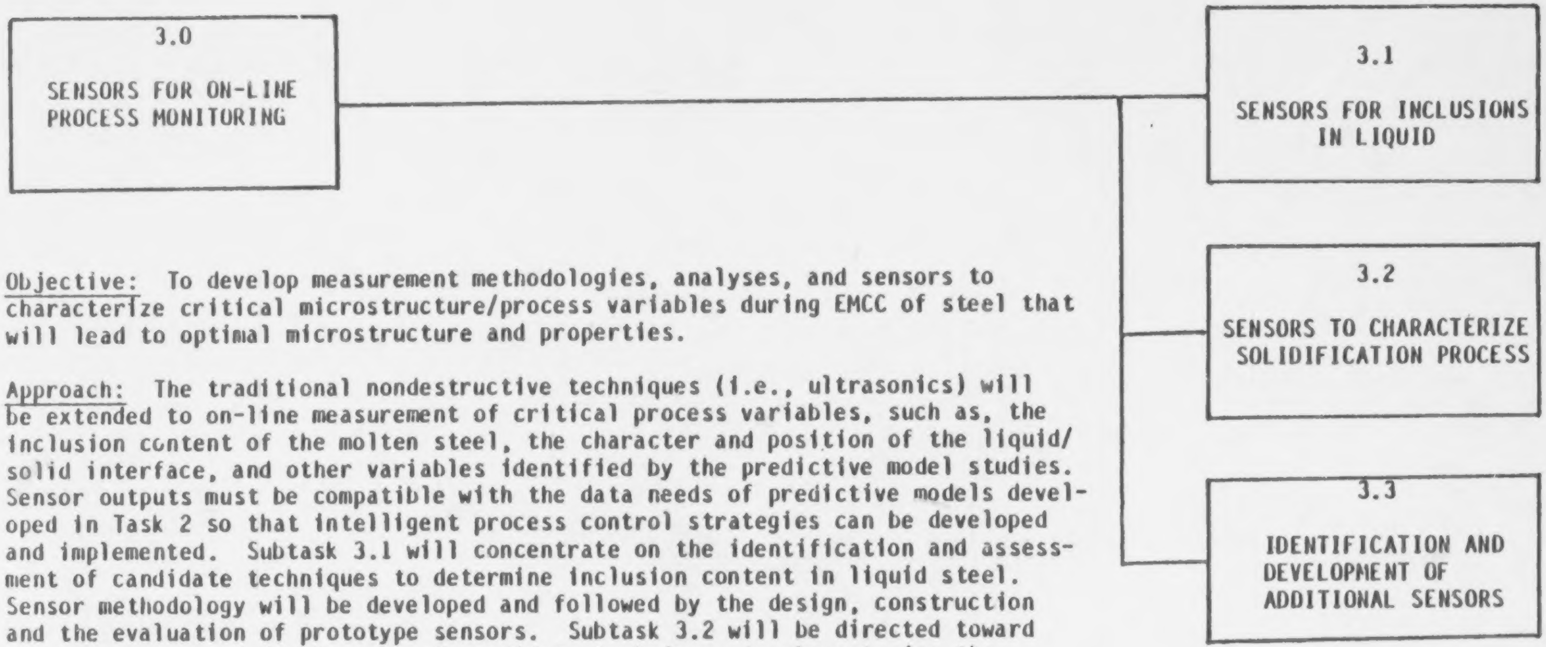
Approach: A comprehensive review of past research and production experience will be conducted. The structure-property relations will be modeled and verified for as-cast steels. The effects of thermal-mechanical processing upon these relationships will be systematically evaluated. The predictive models will be utilized to devise optional thermal-mechanical processing scenarios for large-aspect-ratio shapes. Methods will be developed to minimize scale formation and for scale removal during processing. An instrumented experimental facility will be designed, constructed and operated to verify predictive models and to develop special thermal-mechanical processing techniques for near-net-shape materials.

	SUBTASKS:	FY 1985		FY 1986		FY 1987		FY 1988	
2.3.1	Review current status and develop technology base to relate deformation and annealing processes to microstructures and mechanical properties	9 9	9 9	9 9	9 9	9	9 9	9	9 9
2.3.2	Design, construct, and operate instrumented facilities for direct processing of near-net-size castings to final products*		9 15	15 18	18 18	9 9			
2.3.3	Develop models to predict mechanical properties as a function of cast microstructures		3 3 (6) (6)	3 3 (6) (6)	3 3 (6) (6)	0 0 (6) (6)	0 0 (3) (3)	0 0 (3) (3)	
2.3.4	Develop models to predict responses of cast microstructures to thermal-mechanical processing		0 0 (6) (6)	0 0 (6) (6)	3 3 (6) (6)	3 3 (6) (6)	3 3 (6) (6)	3 3 (6) (6)	
2.3.5	Develop models to predict structures and properties for different deformation and annealing sequences	6	6 9	12 12	12 12	12 12	12 12	12 12	
2.3.6	Develop methods to minimize scale formation and for scale removal during processing	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
	*Capital Equipment: FY 1985 - $500K; FY 1986 - $1000K								
	MANPOWER, MAN MONTHS/MO								

2.3 (Cont.)

THERMAL-MECHANICAL PROCESSING

SUBTASKS:		FY 1985		FY 1986		FY 1987		FY 1988	
2.3.7	Develop thermal-mechanical processing techniques for electromagnetic cast thin sheets and other near-net-size cast materials						3	3 3	6 6
2.3.8	Refine processing models to incorporate individual customer requirements of final properties and minimize number of different grades				6 6	6 6	6 6	6 6	6 6
2.3.9	Develop a comprehensive data base of structure properties for existing grades and for grades developed from direct processing near-net-size castings	6 6	6 6	6 9	3 3	3 3	3 3	6 6	6 6
2.3.10	Develop innovative materials with unique properties as a function of the melting, casting, and thermal-mechanical processing of near-net shapes					18 18	18 18	18 18	18 18
NOTE:	The numbers in ( ) below the activity lines indicate additional manpower contingent on NBS receiving expected funding from the Department of Commerce.								
MANPOWER, MAN MONTHS/MO		8 10	14 17	18 20	21 21	23 23	20 21	22 22	13 18


3.0
SENSORS FOR ON-LINE PROCESS MONITORING
3.1
SENSORS FOR INCLUSIONS IN LIQUID
3.2
SENSORS TO CHARACTERIZE SOLIDIFICATION PROCESS
3.3
IDENTIFICATION AND DEVELOPMENT OF ADDITIONAL SENSORS

Objective: To develop measurement methodologies, analyses, and sensors to characterize critical microstructure/process variables during EMCC of steel that will lead to optimal microstructure and properties.

Approach: The traditional nondestructive techniques (i.e., ultrasonics) will be extended to on-line measurement of critical process variables, such as, the inclusion content of the molten steel, the character and position of the liquid/solid interface, and other variables identified by the predictive model studies. Sensor outputs must be compatible with the data needs of predictive models developed in Task 2 so that intelligent process control strategies can be developed and implemented. Subtask 3.1 will concentrate on the identification and assessment of candidate techniques to determine inclusion content in liquid steel. Sensor methodology will be developed and followed by the design, construction and the evaluation of prototype sensors. Subtask 3.2 will be directed toward the assessment and development of candidate techniques to characterize the solidification process. Other sensors required for process monitoring and control will be identified and evaluated in Subtask 3.3.

3.1

SENSORS FOR INCLUSIONS IN LIQUID

Objective: To develop measurement methodologies, analysis methods and instrumentation to characterize the content and distribution of nonmetallic inclusions in liquid steel.

Approach: A comprehensive review of the current status of sensor development for similar systems in other applications will be conducted. The requirements of sensors for monitoring inclusions in steel will be identified. Research will be conducted to identify candidate technologies and to assess their potential. Prototype sensors will be constructed and evaluated for accuracy relative to the model system. The sensor design will be refined based on operating experience.

SUBTASKS:	FY 1985				FY 1986				FY 1987				FY 1988			
3.1.1 Review current status and requirements	3 (.5)	3 (.5)	3 (.5)	3 (.5)												
3.1.2 Identify and assess candidate techniques	0 (4)	0 (4)	1 (3)	2 (2)	1.5 (3)	1.5 (2)										
3.1.3 Develop sensor methodology	0 (6)	0 (6)	0 (6)	0 (6)	0 (6)	3 (3)	3	3								
3.1.4 Design, construct, and evaluate prototype sensor					0 (3)	0 (4)	0 (10.5)	0 (10.5)	4 (6.5)	5 (5.5)	4 (2.5)	5 (1.5)				
3.1.5 Refine sensor and conduct on-line evaluation * (Thru FY 1989)											4	4	4 (6.5)	5 (5.5)	4 (6.5)	5 (5.5)
*Capital Equipment -$200K																
NOTE: The numbers above the activity lines represent the estimated manpower requirements for the core program. The numbers in ( ) below the activity lines indicate additional manpower contingent on NBS receiving expected funding from the Department of Commerce.																
MANPOWER, MAN MONTHS/MO	1 (3.5)	1 (3.5)	1.5 (3)	1.5 (3)	0.5 (4)	1.5 (3)	1 (3.5)	1 (3.5)	1.5 (2)	1.5 (2)	3 (.5)	3 (.5)	1.5 (2)	1.5 (2)	1.5 (2)	1.5 (2)

3.2

SENSORS TO CHARACTERIZE SOLIDIFICATION PROCESS

Objective: To develop measurement methodologies, analysis methods and instrumentation to define and characterize the liquid/solidification front.

Approach: A comprehensive review of the current status of sensor development for this application will be conducted. Sensor requirements for the EMCC process will be identified and candidate technologies will be assessed. A prototype system will be developed and applied to in-laboratory simulation tests. Further testing will be conducted in pilot plant studies of the EMCC process. The sensor designs will be refined based on the operating experience gained in the pilot plant.

SUBTASKS:	FY 1985		FY 1986		FY 1987		FY 1988	
3.2.1 Review current status and requirements	3 3 (.5) (.5)	3 3 (.5) (.5)						
3.2.2 Identify and assess candidate techniques	0 0 (4) (4)	1 2 (3) (2)	1.5 1.5 (3) (2)					
3.2.3 Develop sensor methodology	0 0 (6) (6)	0 0 (6) (6)	0 3 (6) (3)	3 3				
3.2.4 Design, construct, and evaluate prototype sensor			0 0 (3) (4)	0 0 (10.5) (10.5)	4 5 (6.5) (5.5)	4 5 (2.5) (.5)		
3.2.5 Refine sensor and conduct on-line evaluation* (Thru FY 1989)						4 5	4 5 (6.5) (5.5)	4 5 (6.5) (5.5)
*Equipment - $200K								
NOTE: The numbers above the activity lines represent the estimated manpower requirements for the core program. The numbers in ( ) below the activity lines indicate additional manpower contingent on NBS receiving expected funding from the Department of Commerce.								
MANPOWER, MAN MONTHS/MO	1 1 (3.5) (3.5)	1.5 1.5 (3) (3)	1.5 1.5 (4) (3)	1 1 (3.5) (3.5)	1.5 1.5 (2) (2)	3 3 (.5) (.5)	1.5 1.5 (2) (2)	1.5 1.5 (2) (2)

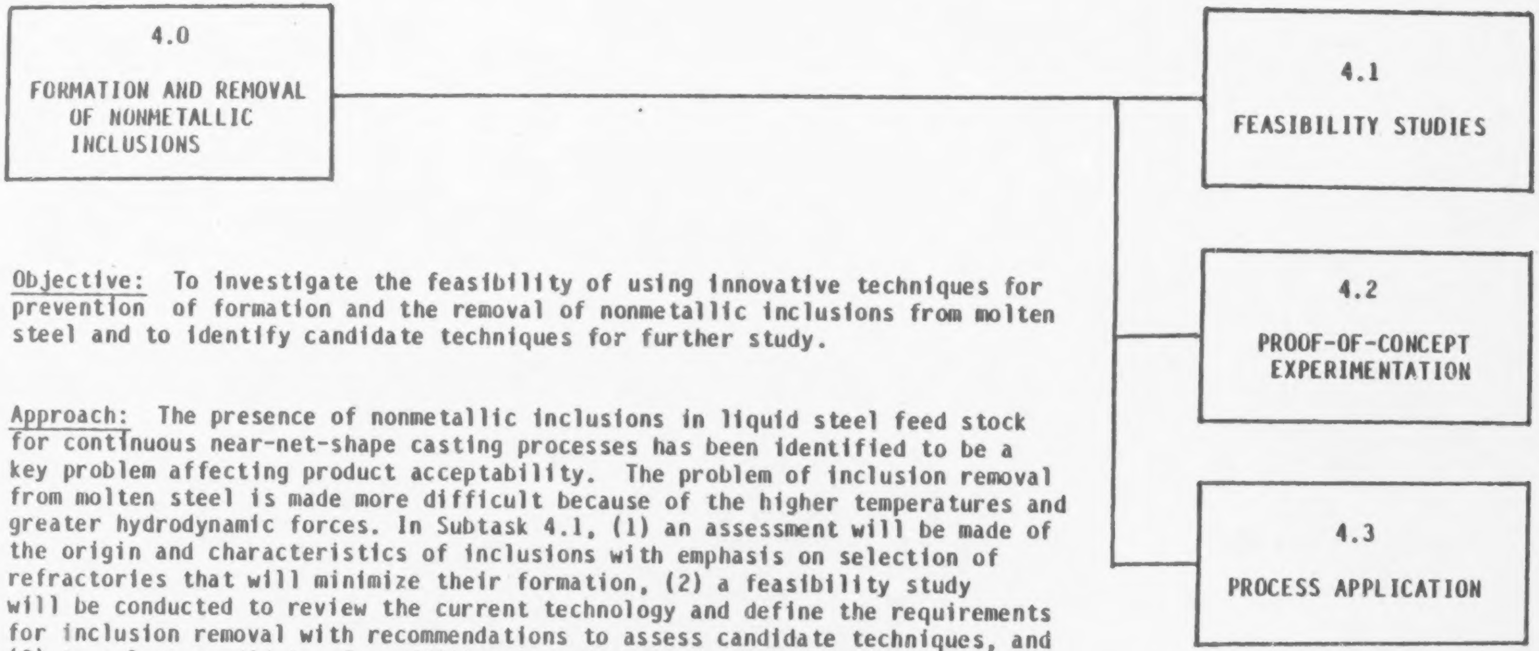
3.3

IDENTIFICATION AND DEVELOPMENT OF ADDITIONAL SENSORS

Objective: To identify and develop additional sensors needed for computer-based control of the EMCC process.

Approach: Predictive modelling studies and pilot plant experiences are expected to identify the need for additional sensors for on-line process monitoring and control. This subtask will develop specifications and assess candidate NDE technologies. Also, the instrumentation and analyses methods will be developed for each sensor.

SUBTASKS:	FY 1985		FY 1986		FY 1987		FY 1988	
3.3.1 Identify additional sensors needed for process control					1 2 (5) (4)	1 2 (5) (4)	1 2 (5) (4)	1 2 (5) (4)
3.3.2 Review current status and projected availability of sensors								
3.3.3 Identify candidate technique								
3.3.4 Develop sensor methodologies								
3.3.5 Design, construct and evaluate prototype sensors								
3.3.6 Refine sensors and conduct on-line evaluation								
NOTE: Schedule and funding of Subtasks 3.3.2 through 3.3.6 are dependent on results from Subtask 3.3.1 and will be determined at a later date.								
MANPOWER, MAN MONTHS/MO					0.5 0.5 (1.5) (1.5)	0.5 0.5 (1.5) (1.5)	0.5 0.5 (1.5) (1.5)	0.5 0.5 (1.5) (1.5)


4.0
FORMATION AND REMOVAL OF NONMETALLIC INCLUSIONS
4.1
FEASIBILITY STUDIES
4.2
PROOF-OF-CONCEPT EXPERIMENTATION
4.3
PROCESS APPLICATION

Objective: To investigate the feasibility of using innovative techniques for prevention of formation and the removal of nonmetallic inclusions from molten steel and to identify candidate techniques for further study.

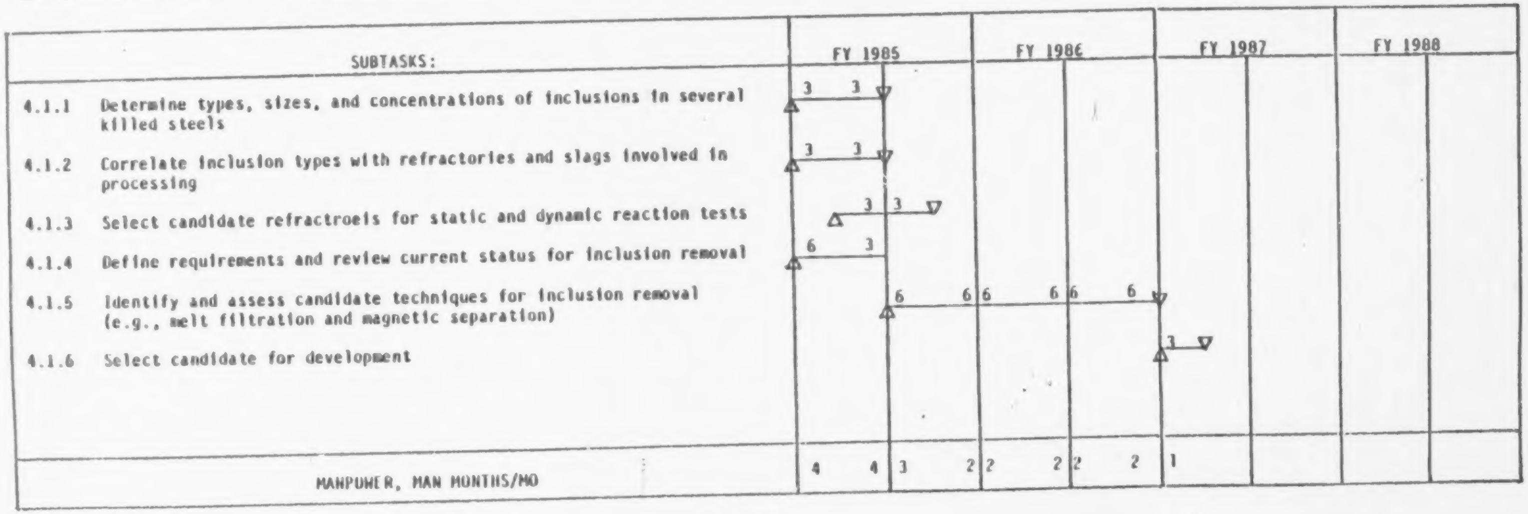
Approach: The presence of nonmetallic inclusions in liquid steel feed stock for continuous near-net-shape casting processes has been identified to be a key problem affecting product acceptability. The problem of inclusion removal from molten steel is made more difficult because of the higher temperatures and greater hydrodynamic forces. In Subtask 4.1, (1) an assessment will be made of the origin and characteristics of inclusions with emphasis on selection of refractories that will minimize their formation, (2) a feasibility study will be conducted to review the current technology and define the requirements for inclusion removal with recommendations to assess candidate techniques, and (3) to select candidates for additional study. The emphasis of Subtask 4.2 will be (1) the experimental evaluation of various refractories under static and dynamic conditions and (2) experimental evaluation of the candidate inclusion removal technique with assessment of the potential of the technique for scale-up. Subtask 4.3 is directed toward the design, construction and evaluation of a prototype system for inclusion removal and is contingent on the success of Subtask 4.2.

4.1

FEASIBILITY STUDIES

Objective: To characterize inclusions formed in steel by current steel-making practices and to select effective methods of prevention of formation of inclusions and to select for experimental evaluation the candidate method having the greatest probability for the successful removal of intermetallic inclusions.

Approach: A comprehensive literature review will be conducted to identify the critical factors affecting type, size, and concentration of inclusions present in steel killed by different techniques. The slags and refractories involved in steel making processes will be characterized. Based on this information other refractories, both commercial and experimental, will be selected for testing aimed at minimizing inclusion content. Criteria will be developed to identify the size and distribution of inclusions that can be accepted in the electromagnetic casting of products with large-aspect-ratio shapes. The candidate technique for inclusion removal will be selected for experimental evaluation. Special emphasis will be given to melt filtration and magnetic separation.



SUBTASKS:

4.1.1 Determine types, sizes, and concentrations of inclusions in several killed steels

4.1.2 Correlate inclusion types with refractories and slags involved in processing

4.1.3 Select candidate refractroeis for static and dynamic reaction tests

4.1.4 Define requirements and review current status for inclusion removal

4.1.5 Identify and assess candidate techniques for inclusion removal (e.g., melt filtration and magnetic separation)

4.1.6 Select candidate for development

MANPOWER, MAN MONTHS/MO

4.2

PROOF-OF-CONCEPT EXPERIMENTATION

Objective: To compare the relative stability of candidate refractories in contact with steel and slags as an indication of inclusion forming tendency and to demonstrate the effectiveness of the selected method for inclusion removal.

Approach: Candidate refractories including those currently used in steelmaking will be exposed to steel and slag under static and dynamic conditions. Refractories with significant potential for minimizing inclusion content will be recommended. Steel killed by different processes will be subjected to inclusion removal by the candidate candidate technique and the results qualified against the selected criteria in Subtask 4.1. Based on the success of this effort, the technique will be assessed for its potential to scale-up.

SUBTASKS:		FY 1985		FY 1986		FY 1987		FY 1988	
4.2.1	Design and assemble apparatus for determining wetting behavior of refractories		△ 3 3 ▽						
4.2.2	Conduct wetting compatability tests under conditions of interest		△ 3	3 3 ▽					
4.2.3	Rank candidates in terms of stability and select candidates for dynamic testing				△ 3 ▽				
4.2.4	Design and assemble reaction system employing relative motion			△ 3 3					
4.2.5	Conduct dynamic exposure tests and analyze samples for reaction products and inclusions				△ 3 6	3 3 ▽			
4.2.6	Identify refractories with significant potential for minimized inclusion content					△ 3 6	3 ▽		
4.2.7	Prepare plans for inclusion removal experimentation					△ 3 3 ▽			
4.2.8	Design and construct experimental apparatus						△ 9 6	6 6	6 6 ▽
4.2.9	Conduct experiments to evaluate concepts						△ 6	6 6	6 6 ▽
4.2.10	Assess potential of system for scale-up								△
MANPOWER, MAN MONTHS/MO			1 2	2 2	2 2	3 4	4 4	4 4	4 4

4.3

PROCESS APPLICATION

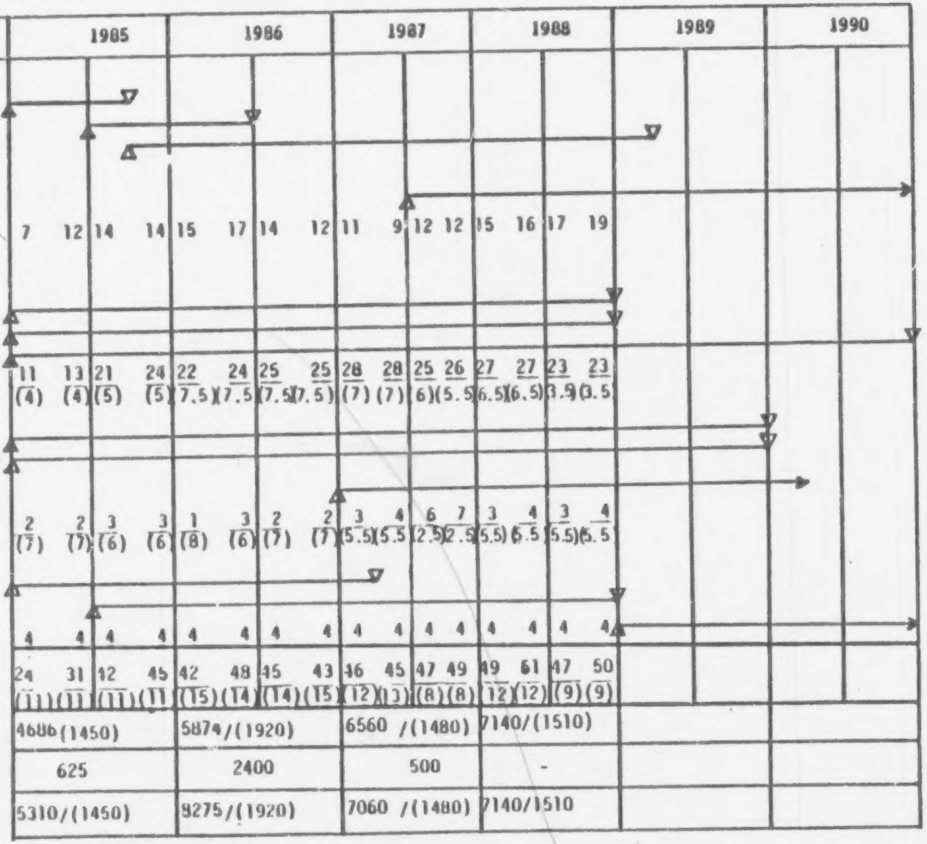
Objective: To demonstrate the capability of the proof-of-concept method for inclusion removal to accomplish the performance goals on a pilot plant scale.

Approach: The prototype system for inclusion removal will be designed and constructed. The pilot unit will be installed in the pilot plant EHCC facility and evaluated for its effectiveness for inclusion removal, and the quality of the cast product will be determined. Data from these pilot plant studies willl be assessed to make recommendations for a full-scale system

SUBTASKS:	FY 1989		FY 1990		FY 1991			
4.2.1 Design and construct prototype system*	12 12	12 12						
4.2.2 Operate and evaluate system			12 12	12 6	6 6	6 6		
4.2.3 Assess potential of system for full-scale application				3				
4.2.4 Recommend additional advanced techniques for development				3				
*Equipment - $200K								
MANPOWER, MAN MONTHS/MO	4 4	4 4	4 4	4 4	2 2	2 2		

ELECTROMAGNETIC CONTINUOUS CASTING PROCESS FOR STEEL

SCHEDULE/MANPOWER/FUNDING



	1985				1986				1987				1988				1989	1990
1.0 ELECTROMAGNETIC TECHNOLOGY FOR CASTING PROCESS																		
1.1 Feasibility and scoping studies																		
1.2 Proof-of-concept experimentation																		
1.3 Laboratory scale-up demonstration of EM continuous casting process																		
1.4 Pilot plant demonstration of EM continuous casting process	7	12	14	14	15	17	14	12	11	9	12	12	15	16	17	19		
2.0 PREDICTIVE MODELS FOR SOLIDIFICATION AND THERMAL-MECHANICAL PROCESSING																		
2.1 Solidification																		
2.2 Solidification stresses and cracking																		
2.3 Thermal-mechanical processing	11 (4)	13 (4)	21 (5)	24 (5)	22 (7.5)	24 (7.5)	25 (7.5)	25 (7.5)	28 (7)	28 (7)	25 (6)	26 (5.5)	27 (6.5)	27 (6.5)	23 (3.5)	23 (3.5)		
3.0 SENSORS FOR ON-LINE PROCESS MONITORING																		
3.1 Sensors for inclusions in liquids																		
3.2 Sensors to characterize solidification process																		
3.3 Identification and development of additional sensors	2 (7)	2 (7)	3 (6)	3 (6)	1 (8)	3 (6)	2 (7)	2 (7)	3 (5.5)	4 (5.5)	6 (2.5)	7 (2.5)	3 (5.5)	4 (5.5)	3 (5.5)	4 (5.5)		
4.0 REMOVAL OF NONMETALLIC INCLUSIONS																		
4.1 Feasibility studies																		
4.2 Proof-of-Concept																		
4.3 Process application	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		
TOTAL EFFORT, MAN MONTHS/MO	24 (11)	31 (11)	42 (11)	45 (11)	42 (15)	48 (14)	45 (14)	43 (15)	46 (12)	45 (13)	47 (8)	49 (8)	49 (12)	61 (12)	47 (9)	50 (9)		
TOTAL EFFORT COST PER YEAR, $K	4686(1450)				5874/(1920)				6560 /(1480)				7140/(1510)					
MAJOR EQUIPMENT, $K	625				2400				500				-					
TOTAL FUNDING, $K	5310/(1450)				8275/(1920)				7060 /(1480)				7140/1510					

NOTE: The additional effort and funding shown in ( ) is contingent on expected NBS funding from the Department of Commerce.

Reference Materials in the Steel Industry

Gold worth $600 an ounce? Maybe. Steel worth $600 an ounce? Not usually.

by: T. R. Linde*

Ted R. Linde is a metallurgical engineer for the product quality and assurance section in the steel group of the Bethlehem Steel Corp. A member of Committee E-2 on Emission Spectroscopy since 1963, Linde has served as chairman of the subcommittees on statistics calibration and on ferrous materials.

When a spectrochemist has only a thin piece of a depleted, nationally certified reference material (CRM), and that tiny piece is essential to ensure that his spectrometer is properly calibrated to confirm the composition of a 300 ton bath of molten metal, steel is worth its weight in gold.

Steel CRMs are available from the National Bureau of Standards (NBS) and national certification agencies in other countries such as Japan, England, France, Germany, Sweden, Poland, and the Union of South Africa. CRMs are extremely valuable due to the integrity of the certification agency, their acceptance worldwide by both consumers and producers, the extensive effort made through consensus analysis in many laboratories to characterize their chemical composition, and their limited supply. For these reasons, it is very important to conserve them. CRMs are indeed as precious as gold in some instances.

It is extremely important to stress the need to conserve CRMs and to minimize dependence on CRMs by developing other reference and in-house materials for lower priority but more frequent use In this way, the supply of critical CRMs can be maintained and certification agencies will be in a better position to make the effort and meet the cost of providing other needed CRMs.

CRMs

Because CRMs made by NBS and other agencies are often as precious as gold, they should be used sparingly. The primary use of CRMs should be for calibration of analytical techniques and instrumentation. A secondary, albeit important, use is in resolving costly disputes between producers and users regarding the composition of materials.

For calibration of an optical emission or X-ray fluorescence spectrometer, available CRMs are analyzed from two to four times over a period of one or, at most, two days when the spectrometer is functioning properly. Concurrently, other appropriate reference materials, either purchased or developed in-house, are analyzed the same number of times. The instrument responses, usually as voltage readings or counts, from the replicate analyses of each material, CRMs and in-house, are averaged. Calibration curves are established by plotting known concentration versus average instrument response for each element determined.

At this point, the CRMs should be removed immediately from the laboratory and stored in a safe, preferably locked, area. They are thus conserved for use months or even years later when recalibration may be required. In this way, a CRM about ¾ in. thick can be retained for many years. In some laboratories, usable pieces are still available ten or more years after the supply from NBS has been depleted. CRMs are too valuable for routine, daily use to verify a calibration curve or standardize the calibration. Controlling instrument curve drift is accomplished by the standardization of the calibration.

Traceability to CRMs

In-house reference materials (RMs) and even uncertified, homogeneous type reference materials should be used instead of CRMs to check a calibration curve or test an analyzer for drift provided they are traceable to CRMs. Traceability to CRMs can be established in two ways. First, as described previously, by analyzing in-house RMs along with CRMs

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*The author wishes to express his appreciation to V. M. Chapman; W. H. Dingledein, Carpenter Technology Corp.; H. C. Dilworth, Armco Inc.; J. E. Joyce, Inland Steel; W. R. Kennedy, American Cast Iron Pipe Co.; and H. G. Zelinske, Amsted Research Labs, for their contributions to this article.

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As a technician develops an in-house reference material, he must constantly pull samples to make sure the contents meet the specifications required for it. Here, a shot sample is poured for a carbon and sulfur analysis.

during calibration and establishing their relationship to CRMs. The second way is to use CRMs for control of the referee analytical procedures that are employed to establish the composition of the in-house RMs. Either approach is acceptable when proof of traceability is required. Providing traceability both ways on the same material is preferred.

Development of In-house Materials

In-house RMs can be made from an ingot of steel from a special heat, a portion of continuous cast material, or from selected material taken from production heats, such as a billet. If a billet is taken from production, it is usually advisable to select one that was rolled from the middle of an ingot to avoid the segregated top or bottom of the ingot. Material for in-house RMs can also be obtained by acquiring bars or rods of the desired grade from production heats. Regardless of the source of candidate material for in-house RMs, the desired final form of the material must be considered before fabrication can begin.

Form of SRMs

Steel RMs are usually made in one or more of three forms.

1 Round or square disks, about 1 to 2 in. across and about 1 in. thick, for use with optical emission and X-ray spectrometers.
2 Approximately 1 g pins of convenient diameter for use with combustion carbon and sulfur analyzers.
3 Millings or chips for use in wet chemical analysis and with combustion analyzers.

Quantity of Material

Another consideration is the number of pieces required. A long-term supply of each in-house RM is desired to minimize the frequency of replacing materials and to spread the cost of fabrication and certification over a large quantity of material. How a specimen will be used must be assessed. How many laboratories need it? How often will it be analyzed? Will the material deteriorate in storage? This information is needed to calculate how much raw material is needed. Also, based on experience, additional materials should be processed to compensate for loss that occurs through elimination of segregated portions and provide sufficient reserve material for possible future use. It is not unusual, when fabricating solid specimens, to discard one-half to two-thirds of the original material to ensure adequate homogeneity of the remaining portion to be fabricated into an RM.

Typical quantities of in-house RMs that would meet the requirements of a large steel mill laboratory for a period of approximately 20 years are given below.

Disks—100 to 200 pieces
Pins, lg.—100,000 to 500,000 pieces
Millings[1]—20 to 100 lb

Initial Homogeneity Testing

After sufficient candidate material is obtained, extensive analytical tests must be made to assess material inhomogeneity. ASTM E 826, Practice for Testing Homogeneity of Materials for the Development of Reference Materials, describes a procedure for this testing. The method describes how to evaluate the data from that test statistically.

In general, regardless of the initial form of the raw material, ingot, slab, billet, or bars, samples are taken from the candidate material and analyzed spectrochemically to verify that the composition does not vary significantly from top to bottom of each piece, from center to edge of a cross-section of each piece, and between different pieces. Based on these tests, material that is inhomogeneous should be discarded.

In the case of an ingot of steel, typically about 20 percent of the material from the top and 10 percent from the bottom, show evidence of segregation for some elements. Segregation will cause inhomogeneity in the finished product if not removed. Usually those parts of the ingot are cut off and discarded before the cross-section testing is begun for homogeneity. Such testing often shows segregation running lengthwise through the center. When that occurs, the ingot can be rolled into a slab and the undesirable portion removed.

In some cases, it may be more economical to roll the candidate material directly to the final bar size and then test for homogeneity. This approach eliminates the initial homogeneity testing, but could result in unnecessary and expensive fabrication steps if the rolled material is not acceptable.

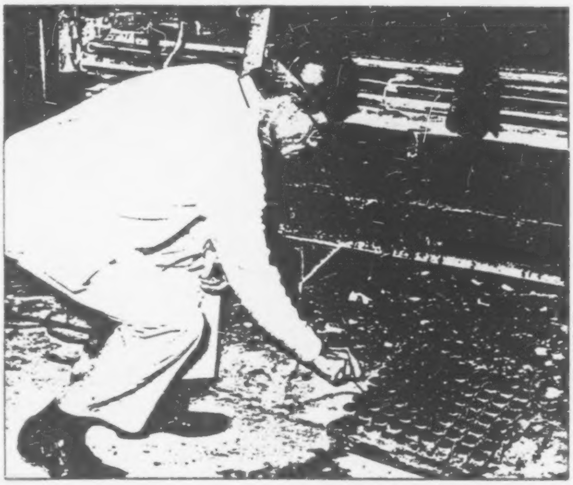
Fabrication

After homogeneous material is identified, it can be processed into bars by rolling or forging to make disk samples, or $7/32$ in. wire and cut to length to make 1 g pin samples, or chips by milling. More popular grades are produced in all three forms.

Final Homogeneity Testing

After fabrication, additional homogeneity testing is performed to guarantee that all material on hand has acceptable uniformity. Such tests are made prior to certification analysis to avoid costly and time consuming analytical effort in case the material is not acceptable. This can be done by taking samples, six to eight are usually adequate, from different portions of the fabricated material and analyzing them according to a plan to prove that all samples are alike in composition. Some laboratories test every bar at this point. ASTM E 826 describes how to set up and evaluate such a test.

After samples of alloy steel have been made, each is assigned a number. These samples are then analyzed to ensure that their composition has a certain homogeneity, which relates to the integrity of the entire cast.



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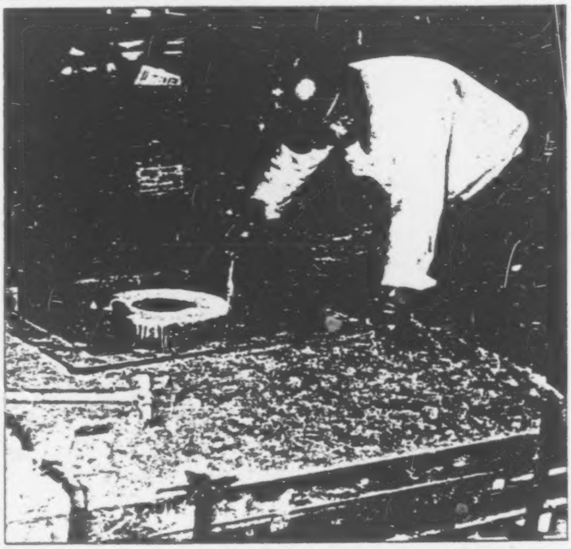
[1] Some laboratories prefer to use millings rather than lg. pins with carbon and sulfur analyzers. In those situations, it may be advantageous to produce more than 100 lb.



In-house reference materials can be made in small quantities by casting molten steel in a steel or copper mold. Here nine stoppers are in place. After molten metal is poured into the coated sand tundish, the stoppers are released, allowing the metal to flow into the mold and to cool on the copper plate.

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Certification Analysis

If the target specifications for acceptance are met, analytical work can begin. Since umpire or referee methods of analysis are usually employed to certify composition, millings are required for analysis. If millings were not provided from the raw material, chips must be obtained either from the rolled bars or pins, or from a piece of the material that was found to be acceptable.

These millings are then submitted to competent laboratories for analysis. The analyses should be done in more than one laboratory to average any bias that may exist in a single laboratory. Three or more laboratories are preferred. The millings should be analyzed in each laboratory in duplicate on several different days using ASTM referee chemical techniques or other proven methods of analysis, and analyzed using NBS or other nationally certified CRMs for calibration and control.

The results from all laboratories should be tested statistically for outliers using ASTM method E 876, Practice for Use of Statistics in the Evaluation of Spectrometric Data. All acceptable values should be averaged to obtain the assumed true value. This procedure, when used to certify composition, provides traceability to nationally certified CRMs.

In-house Carbon-Sulfur RMs

In-house RMs for calibration and control of combustion carbon-sulfur analyzers can be made in the form of millings or 1 g pins. One gram pins are more convenient to use than millings because they can be weighed and inserted into the analyzer with minimum effort.

The first step in making 1 g pins is to select homogeneous material. The material may be in the form of a billet, but could be a bar or rod. The selected billet or bar is rolled into a rod, normally $\frac{7}{32}$ in. diameter. Both ends of the rod are then tested for similarity. If the carbon and sulfur do not vary significantly from end to end, the rod is cut to approximate length and centerless ground to provide pins of approximately 1 g weight. Manufacturers of roller bearings fabricate pins from rods at relatively low cost. To provide an adequate supply of 1 g pins for use in a number of laboratories, one major steel manufacturer processes an unbroken, 3,000 lb coil of rod into approximately 1,300,000 pins. A 300 lb coil will produce at least 100,000 pins. These pins can be packaged in lots of 15,000 in sealed steel cans or in bottles containing about 500 pins. Different coils from the same heat should be kept separated throughout the processing into pins and final packaging should be identified by coil.

Millings for use with combustion analyzers are made by machining a billet, bar, or slab of steel, followed by screening, blending, and packaging.

Cast Disk In-house RMs

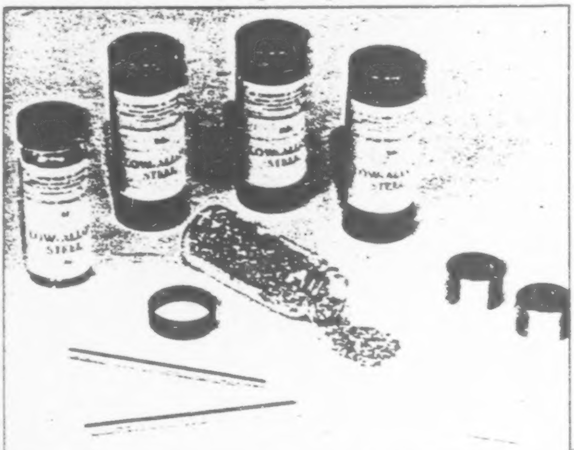
In-house RMs can be developed in the form of cast disks. One disadvantage of cast disks is that a sufficient number of specimens is difficult to obtain because the same amount of analytical effort is required to certify one, ten, or a 1,000 disks. A second disadvantage is the relatively high analytical expense per cast required to confirm the compostion of this relatively small number of disks. However, there may be no alternative than to develop a small quantity of cast disk materials. When a special material is needed, perhaps for limited use in only one laboratory, a dozen disks can be cast simultaneously from molten metal in a gang mold. With proper design, the disks cast in a gang mold will have similar metallurgical structure as normal production cast samples, such as those used by the laboratory to obtain the required production analysis. At least one supplier provides 72 specimens per cast from excess metal of production heats but not of all compositions. At this time, such molds are not commercially available.

In-house RMs can also be made in small quantities by casting molten steel in a steel or copper mold. The casting, about 6 to 8 in. long and 1½ to 2 in. in diameter, can be cut into disks about 1 in. thick. One or two disks must be sacrificed to establish composition by wet chemical methods of analysis. The others are available for spectrochemical use. This approach must be used with caution. Material cast this way may have a slightly different metallurgical structure than production samples from the same molten material, particularly if the production disk was cast on a chill plate.

Control of Analytical Instrumentation

If in-house RMs are available in relatively large quantities, they can be used for daily control of calibration curves. Thus, after the calibration is defined, one or more of the in-house RMs can be used as required to ensure that the instrument calibration is still valid. If in-house RMs are not available in sufficient quantities, uncertified homogeneous materials can be used for periodic control and verification of calibration curves. Such material must be tested to ensure homogeneity. In addition, the relationship of that material to the calibration curve must be clearly defined through multiple determinations.

Certified reference materials (CRMs) made by the National Bureau of Standards (NBS) are often considered as precious as gold. Their primary use should be for calibration of analytical techniques and instrumentation.



When the control RM is analyzed and shows that the calibration has drifted outside the control limits, corrective action must be taken. This usually means standardization of the calibration is required. The control RM should be analyzed again immediately after standardization to prove that the standardization was effected. Refer to ASTM E 305, Recommended Practices for Establishing and Controlling Spectrochemical Analytical Curves, for additional information.

Occasionally, a slight bias may exist between CRMs and in-house RMs. If this happens with an in-house RM that is used for calibration control, a value other than its analyzed value is assigned to the in-house RM when it is used for calibration control. For example, if an in-house RM with an assumed true value of 0.37 percent reads 0.38 percent from the calibration curve drawn through CRMs, a value of 0.38 percent can be assigned to it in order to correctly control the calibration curve.

Metallurgical Problem with In-house RMs

A common problem often encountered is a different spectrometer response between cast and rolled samples of the same material. This is a metallurgical problem because most certified reference and in-house RMs are fabricated by rolling or forging, whereas production control specimens are chill cast disks. Steel specimens fabricated by rolling or forging, as are many CRMs, have a different metallurgical structure than those cast from molten metal. In turn, such materials often produce different spectral response than cast disks when excited in the spectrometer. For this reason, forged or rolled CRMs frequently cannot be used directly to calibrate for analysis of steel materials cast from molten metal. A prime example is spectrometer determination of sulfur. At a concentration of 0.030 percent sulfur, the actual sulfur content of a cast disk may be 0.002 percent less than the analysis obtained using a calibration curve based on CRMs that were fabricated by rolling. When this situation arises, about 50 to 100 production cast disks should be chemically analyzed for sulfur by referee techniques using CRMs for control. Then a new calibration curve is established using the values from the analyzed cast production disks. The relationship of cast disks to CRMs is established and documented in this way, even though CRMs cannot be used directly to accurately define the calibration curve. ●

Mr. FUQUA. Thank you very much, Dr. Leonard.

Dr. Elliott.

STATEMENT OF DR. JOHN F. ELLIOTT, PROFESSOR OF METALLURGY, DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MA

Dr. ELLIOTT. Mr. Chairman and members of the subcommittee, my name is John Elliott, and I am a professor of metallurgy in the Department of Materials Science and Engineering at MIT.

I have a prepared statement here, and I submit this for your review, but I would also like to comment on it. I will try to be brief because I realize that time is running on.

First, let me say that I have been at MIT for 30 years, and prior to that time, I was a researcher and a metallurgist in the steel industry.

In the past year, I have participated in discussions with regard to this Keyworth initiative, and also, I participate as a consultant to Bethlehem Steel Corp. on the thin-slab casting project.

Further, this fall I was an observer at the K-R pilot plant of Korf Engineering in Kehl, Germany, where American raw materials were being tested in the K-R process, but more of that in a few minutes.

First, I would like to make a statement on sort of a matter of principle that I think is very important and ought to be placed before this group as we think about the problem of the American steel industry and its technology.

It is to be expected that methods and processes now in use will continue to be improved and that new methods will appear.

I share the concern with many people that all segments of the American steel industry may not have a competitive technological base in the years to come. To survive in the longer term, the industry must continue to advance its technological base. It is not to be expected that the research and development activities of an organization should have all bases covered.

On the other hand, a weak or absent capability in areas of science and technology of importance to that industry makes it vulnerable to competitive forces—that is true today; it will be true 10 years from now—unless there is present an overwhelming advantage in other areas of the organization's activities such as low-cost raw materials, low-cost labor, or capital available at preferred rates, unfortunately, none of which applies to the American steel industry.

It has been argued that in the more traditional industries such as steel, improvements in technology by other organizations or countries can be obtained at a relatively low cost, and in fact it is cheaper to buy the know-how and use of patents than to develop them. This position ignores two important considerations. In the first place, an organization without a strong indigenous scientific and technological base may not have the capability to adopt and use technological advances rapidly and effectively. In the second, the organization that does possess advanced methods may not be willing, or may not be required, to pass on its latest improvements to a competing organization or company. The pattern of the last several decades where use of advanced methods flows relatively easily from country to country, especially regarding steel technology, may not be true in the future, especially with increasing international competition in science and technology.

I would like now to go to this issue of iron smelting and steelmaking. As Dr. Leonard pointed out, the American steel industry depends on coke ovens and blast furnaces for smelting iron ore. Many of these plants are no longer technically competitive with similar facilities in other countries. New methods for smelting ores are needed to help restore the competitiveness of the industry and to permit the industry to utilize coal directly in the smelting process, rather than being dependent upon coke as the fuel.

Of course, this is a central issue in the areas selected for work under the Keyworth initiative. There are several new processes in various stages of development that are based on coal as the fuel. Essentially all of them are being developed either in Europe or in Japan.

The K–R process that I mentioned earlier is in the pilot stage, and a 6-ton-per-hour pilot plant has been in operation in West Germany for several years. This process shows promise of being able to meet some of the needs of the American steel industry in the nearer term.

However, even if it does, it is prudent for this country to continue research and development on innovative methods for smelting and refining iron and steel with coal as the primary fuel.

Now, there are a whole array of issues that need to be looked at for the long-term development of technology.

Speaking of the Keyworth initiative, the programs of research being considered under the Keyworth initiative are primarily modeling of process steps in iron and steelmaking, possible new methods for smelting ores to steel, which has a containment problem; that is, how does one hold this reacting system, either in refractories or by some other special design system, for the smelting processes and the near net shape casting of crude steel.

To be brief, I have made my comments very specific on these. First, I must say that in the planning and the development of the program for the Keyworth initiative and the research under that, it seems to me that one needs to be very careful to be sure that we have a matching in the abilities of the background of research people who are from both industry and the industrial laboratories to match the needs of the research program. The needs of the program should be well defined as one goes forward with that planning.

The work on direct smelting methods should be directed to the longer term goal of major innovations and smelting methods and should be generic in character; that is, there are basic ideas, basic problems, basic issues that should be focused on, because these issues are going to be present in most any kind of smelting system.

One then has background information on which one can base the development of specific processes. This generic work should be carried on whatever the results from the current pilot plantwork now in progress on processes such as the K–R process and others.

The containment of the materials, gases, and metals in smelting processes is a serious issue in the development of these new smelting processes. The generic problems in containment should be given attention for the longer term. Again, it is a similar issue that I mentioned with regard to the smelting process itself.

When the research on smelting methods has proceeded to where a process is being developed, then specific problems that arise from the nature of the process should be addressed. I think as one plans this program of smelting research, this should be kept in mind because one can solve problems that may not be actual problems in the longer term.

The work on modeling should be coordinated closely between the investigators in the national laboratories and knowledgeable people in the industry. There are important and subtle relationships among the steps in processing systems that must be addressed, and those who are not familiar with the details of a process may miss those subtleties. It seems to me that close cooperation, close coordination, must be assured if we are going to be successful in that portion of the initiative.

The near net shape casting of steel with the use of magnetic effects is a somewhat specialized effort. It would be advisable that work on methods of sensing of the important parameters in the casting method be included in the current program, and they should come along fairly early.

The Thin-Strip Casting Program and the Thin-Slab Casting Program for steel that are being sponsored by the Department of Energy are not in direct competition with the near net shape casting process. The thin-slab casting effort is near term. The thin-strip casting method is longer term, and the near net shape casting is also longer term, but it applies in general to different types of products.

I might add that the near net shape casting is going to be developed from Argonne's capability in handling magnetic fields and magnetic effects. Now, the induction effects are being used in the other casting processes, but they are used in a different way and for somewhat different purposes, and one should not confuse the kinds of efforts that are needed for the use of magnetic fields in each of them.

There are several other comments on the program, the Keyworth initiative, that may be helpful. First, there must be a good match of the talents of the people in the national laboratories and the issues being investigated. This may be a problem in some cases because of the direction in which the national laboratories research has been headed over the last several decades, and the technology of steelmaking is different from that.

Also, to make best use of able talent that may be available, it would seem advisable that the research programs include participation by academic institutions on a selective basis. If you remember, the Packard report said industry, government, and academia.

A considerable body of understanding and expertise is available in a number of universities that should be of value to the program, and I could respond to that with further questions if you would like to explore it.

Finally, there are many areas of research and development related to improving the technological base of the American steel industry in the longer term that are not being covered by the Keyworth initiative. It is important that research by the industrial and academic laboratories be carried out on a selective basis. The academic participation is essential because the industry must have adequately trained scientists if it is both to develop and utilize technological advances that may be made.

There is a danger of the diminution in support for research in the universities that relates to the long-term technological needs of the industry. There is a tendency by some to think that the Keyworth initiative carries the full load of research for the steel industry, and I think that is a very dangerous situation, and we should not let that be the case if we proceed with this program.

In a way, there is danger of the industry putting all its eggs in one basket, and I think we have to be wary of that problem.

Thank you.

[The prepared statement of Dr. Elliott follows:]

March 7, 1985

STATEMENT BEFORE THE SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

Hearing on Fiscal Year 1986 authorization for the Department of Energy's Conservation Programs

by

John F. Elliott

Mr. Chairman and Members of the Subcommittee:

My name is John F. Elliott. I am Professor of Metallurgy in the Department of Materials Science and Engineering at the Massachusetts of Technology. I have been on the faculty of MIT for thirty years. My professional work in teaching, research and consulting is in the areas of Chemical and Extractive Metallurgy with principal emphasis on the metallurgy of iron- and steelmaking. In the six years prior to joining the faculty at MIT, I was employed by Inland Steel Company, and earlier by the United States Steel Corporation. My work with industry was in research and in metallurgy of production processes. I have been designated The American Iron and Steel Institute Distinguished Professor by that institution.

This past year, I have participated in discussions and planning for the Keyworth Initiative to involve one or more of the National Laboratories in research and development work that is directed to improving the technological base of the domestic steel industry in the longer term. I participate as a consultant to the Bethlehem Steel Corporation in the Thin Slab Casting Project that receives financial support from the Department of Energy. The program is being carried out jointly by The Bethlehem Steel Corporation and The United States Steel Corporation. Late last fall, I was an observer at the K-R Pilot Plant of Korf Engineering in Kehl, Federal Republic of Germany, when American raw materials were being tested in the K-R Process for smelting iron ores with coal as the fuel.

Competition and Research

The technology by which steel is manufactured has advanced dramatically in the past decade, and it is to be expected that the methods and processes now in use will continue to be improved and that new methods will appear. I share the concern with many people that all segments of the American steel industry may not have a competitive technological base in the years to come, and to survive in the longer term, the industry must continue to advance its technological base. It is not to be expected that the research and development activities of an organization should have all possible bases covered. On the other hand, a weak or absent capability in the areas of science and technology of importance to the industry makes it vulnerable to competitive forces, unless there is present an overwhelming advantage in other areas of the organization's activities. Examples are very low cost raw materials, low labor costs, or capital available at preferred rates, none of which applies to our steel industry.

It has been argued that in the more traditional industries, such as steel, improvements in technology by other organizations or countries can be obtained at a relatively low cost, and in fact it is cheaper to buy the know-how and use of patents than to develop them. This position ignores two important considerations. In the first place, an organization without a strong indigenous scientific and technological base may not have the capability to adopt and use technological advances rapidly and effectively, and in the second, the organization that does possess advanced methods may not be willing, nor may it be required, to pass on its latest improvements to a competitive organization or company. The pattern of the past several decades where the use of advanced methods flow relatively easily from country to country may not be true in the future, especially with the increasing international competition in science and technology.

Iron Smelting and Steelmaking

The American steel industry depends on coke ovens and blast furnaces for smelting iron ores. Many of these plants are no longer technologically competitive with similar facilities in other countries. New methods for smelting ores are needed to help restore the competitiveness of the industry, and to permit the industry to utilize coal directly in the smelting process rather than being dependent on coke as the fuel. There are several new processes in various stages of development that are based on coal as the fuel. The K-R Process is the pilot-plant stage, and a 6 ton per hour pilot plant has been in operation in West Germany for several years. This process shows promise of being able to meet some of the needs of the American steel industry in the nearer term. However, even if it does, it would be prudent for this country to continue research and development on innovative methods for smelting and refining iron ore with coal as the primary fuel.

The Keyworth Initiative

The programs of research being considered under the Keyworth Initiative are primarily concerned with modeling of process steps in iron- and steelmaking, possible new methods for smelting ores to steel, the "containment problem" for smelting processes and near-net-shape casting of crude steel. Several comments on these programs may be helpful:

- The work on direct smelting methods should be directed to the longer term goal of major innovations in smelting methods and should be generic in character. This work should be carried out whatever results from the current pilot plant work now in progress on processes such as the K-R Process, and others.

- The containment of the materials, gases and metal in smelting processes is a serious issue in the development of a new process. The generic problems in containment should be given attention for the longer term. When the research on smelting methods has proceeded to where a process is being developed, then problems specific to the process should be addressed.

- The work on modeling should be coordinated closely between the investigators in the National Laboratories and knowledgeable people in the industry. There are important and subtle relationships among the steps in processing systems that must be addressed.

- The near-net-shape casting of steel with the use of magnetic effects is a somewhat specialized effort. It would be advisable that work on methods of sensing of the important parameters in the casting method be included in the current program.

- The Department of Energy is supporting the development of thin slab casting which is a near-term effort, and thin strip casting which is longer term. The near-net-shape casting program planned for the Argonne National Laboratories is also longer term, but it has important similarities to the thin-strip casting program.

There are several other comments on the programs of the Keyworth Initiative that may be helpful. To make the best use of able talent that may be available, it would seem advisable that the research programs include participation by academic institutions on a selective basis. A considerable body of understanding and expertise is available in a number of universities that should be of value to the program.

There are many areas of research and development related to improving the technological base of the American steel industry in the longer term that are not being covered by the Keyworth Initiative. It is important that research by the industrial and academic laboratories be carried out on a selective basis. The academic participation is essential because the industry must have adequately trained scientists and engineers if it is both to develop and utilize technological advances that may be made.

DISCUSSION

Mr. **Fuqua**. Thank you very much, and let me thank each of you for a great contribution to some of the dilemmas and deliberations that we are making.

Dr. Leonard, you and Dr. Elliott talked about the Keyworth initiative and the work, also, as a result of the Packard report, something that we in this committee have been very interested in for some time and have, in the past, held hearings on in terms of the further involvement of the national laboratories or making them available to industry as well as having academia have an opportunity to participate in those laboratories, and we still have not been pleased at what has happened, but it is a step in the right direction.

I noticed in looking through the budget—and as you mentioned, I think, Dr. Leonard—that there are not any funds provided in the budget. I am almost shocked that something that has had as much thought and careful consideration as not only the Packard report but also the Keyworth initiative, that the Department of Energy or the Office of Management and Budget did not see fit to put some funds in the budget request for this. I find none anywhere, and you have indicated that there are no funds.

Dr. **Leonard**. That is our understanding, yes.

Mr. **Fuqua**. It is just shocking that that has been permitted to happen.

How much money do you think it would take from DOE to begin a modest phase of the Keyworth initiative, both from DOE and also, you indicated, from industry, from the Iron & Steel Institute as well as industry itself?

Dr. **Leonard**. Mr. Chairman, thank you for your comments, first of all.

In response to your question, our judgment is that the package which I mentioned, which is about $14 million a year total, is about as small as we can go and still do something significant here.

I mentioned earlier that there has already been a lot of study done and——

Mr. **Fuqua**. Now, that is a total amount of $14 million?

Dr. **Leonard**. That is correct, of which $10 million per year would be DOE funds through the national laboratories; $2.5 million would be for Department of Commerce via National Bureau of Standards; and the remaining $1.5 million per year is coming directly from the steel industry itself.

Our judgment is that that is the minimum package that is doable, and I emphasize that there have already been a number of study committees come together to try to boil the thing down to a minimum doable package, and it has these two pieces in it that Professor Elliott has described. So that is our recommendation.

Mr. **Fuqua**. We are talking about in both cases, I think, in the DOE as well as the Bureau of Standards, there has been no money provided.

Dr. **Leonard**. That is correct.

Mr. **Fuqua**. So that puts us in the untenable position of coming up with $12.5 million in funds that have not been requested which, in the budget this year, is pretty tough. Let me say it is worse than tough.

Dr. **Leonard**. I understand how difficult that is. I can only say in response that this is a program which I believe has demonstrated bottoms-up solidity to it, a reality that is rarely at this stage to be found, especially when it involves joining our treasures in the national labs and other Government agencies with industry and with universities. This is a rarity.

It is worth funding it. I have to repeat that. I understand the difficulty of it. I can only hope that somehow in the process we can find a way to do that.

Mr. **Fuqua**. Dr. Elliott, how would you say that the universities could contribute to this in the extent of their involvement?

Dr. **Elliott**. Well, the universities, the faculty and research staff, have certain competencies in understanding a number of the scientific and technological issues that are important, for example, to this potential for the long-term development of a direct smelting process.

Now, it seems to me there could be a partnership with regard to this kind of work; that is, that the talent that is needed for the development of this technology does not reside only with the national laboratories. In fact, one can argue there may be more talent capable to focus on these issues in the academic institutions than in the national labs, but that is a matter of where is the program going, and one cannot say at the moment how the split ought to be.

But it seems to me the national laboratories have the capability of putting together relatively large-scale equipment, relatively sophisticated pieces of apparatus. They have highly technical sensing devices and the like. It would be appropriate for work involving that kind of equipment to be placed in the national laboratories. It is expensive; it requires maintenance staff; it requires an operating staff; and it is really not totally suitable for academic work.

Now, the academic programs could be related to the more fundamental aspects of certain of these problems, and they could interact with the national laboratory people in bringing not only new ideas into the system to interact on potential ideas, but also to share in the use of these specialized pieces of apparatus that might be pertinent to the ideas and subjects that they are doing research on.

But I would propose that there are issues of innovation, and merely getting the computer together and running a computer with a large number of people who can write down the models does not necessarily provide the innovative process, and so we need minds that are able to think about the field, to bring together fundamental ideas and put them together into concepts that need to be evaluated and pursued if they make sense. Then the modeling effort seems to be suitable as a means of evaluating which particular kind of process that is being proposed would be suitable.

So it seems to me that there could be a partnership, and I would hope that this partnership would involve industry, the national laboratories, and the academic world. I don't think that it is a major-scale effort. I think that one can be selective and pick the people who have competence, pick the organizations who have the right background and that could make a significant contribution.

Mr. **Fuqua**. Dr. Leonard, you said that industry could participate at about $1.5 million. Assuming that the research R&D tax credits are extended beyond this year, would it be possible to get more support from industry than what you are proposing, or what you suggested on that?

Dr. LEONARD. I understand your question.

First of all, in the current circumstances, I am sure you appreciate that in the loss position that virtually all of us in the steel industry are in, that does not help us at all. If we are fortunate enough to find our markets turning up in the next year or so, certainly that will give added ability for us to increase our contribution.

I would note that this contribution is in the form of, at present, 15 key scientists from the industry who will work on site with their Federal counterparts. If we are successful in our marketplace, we would dearly love to increase that participation.

Mr. FUQUA. Mr. Poirier, in your remarks you indicated that the European firms were focusing on R&D, on heat exchangers, cogeneration, process control, fluidized bed boilers. Given the focus of the European activity, are the industrial program R&D activities focused on the appropriate mix of technologies to assure that the United States will remain competitive?

Mr. POIRIER. Yes, in my opinion, I believe they do. As a matter of fact, a comparison of the portfolio of activities supported by OIP and the portfolio of activities supported by AFME, EEO, or STU in Sweden shows a striking resemblance. In fact the OIP would be developing those very activities that would be developed also in Europe. So to that extent, I think you can say that the OIP is definitely on the right track.

Mr. FUQUA. You mentioned greater involvement of the private sector in the Department of Energy's industrial programs. How would you suggest that those programs be structured? Does it fit with the activities currently conducted by DOE?

Mr. POIRIER. Well, that recommendation comes really from an observation. That is that, like OIP, the counterparts of OIP in Europe have always involved the private sector in one way or another, but lately, especially in the last 2 or 3 years, they have definitely made attempts to increase private sector involvement in a very systematic and highly visible way.

Let us take two examples, the EEO in the United Kingdom and the AFME in France. They both receive private sector input at a very high level in the form of recommendations coming from advisory boards where private sector people appointed by the government sit and provide input.

But, even more specifically, that private sector involvement really comes at different stages of the R&D process. It comes at the conceptualization stage. Take the example of Sweden. Trade associations had worked with the STU, the Swedish technical agency, for almost a year before they developed their last 3-year program.

The second stage will be the selection of the proposal. For example, in the United Kingdom there is a committee that reviews the proposals, and that committee has private sector people involved.

The third stage is really the execution of the R&D projects. In a lot of the European countries, R&D is being sponsored directly by trade associations, and members of the trade associations, private companies, would detail project managers for specific projects.

Fourth, in the marketing—I don't want it to sound like a dirty word—but in the technology transfer and marketing of technologies, you see the example of the EEO where there is a marketing department, and that department benefits from the help of five private sector marketing specialists who are also commissioned and appointed by the government.

There is also a very strong private sector involvement through regionalization, with the local chapters of the trade association getting involved. I realize there are differences in the institutional and legal framework between the United States and the European countries, but the fact is that those European countries have been able to come up with those new ways of getting increased participation in the private sector, and yet those European countries are different; they have different frameworks. But they have been able to get around that problem one way or another.

Mr. **Fuqua**. Dr. Kelleher, you mentioned your pulp and paper mills, and I might add that two of them—one in Jacksonville and one in Pensacola—supplied a large part of their product out of my district, which is in between those two cities.

Dr. **Kelleher**. Yes.

Mr. **Fuqua**. Now that the economy is beginning to experience some growth, is there still a need for Federal funding for new process technology?

Dr. **Kelleher**. I think the need continues very strongly. We have experienced several rough economic years, and we are, too, starting to come out of them, but we have on the shelf hundreds of projects that have been held in abeyance for an improved economic climate.

The types of projects being supported with the DOE tend to be very fundamental and address fundamental energy conservation issues. There is a definite need for that funding to continue.

Mr. **Fuqua**. We keep hearing from the administration that if we can just do the basic research, then the economic incentives are such in the marketplace that you will be falling all over each other in order to implement them and move them forward.

From what I gather, I think, from all four of you gentlemen, that is not the case. There is a role, and an appropriate role, for Federal support to try to help move these technologies forward.

I don't remember which one of you mentioned it, but I have heard it many, many times, that where it is high risk, until it is proven conceptually in a commercial-type atmosphere and there is more proof of concept, it is very risky for a company to invest a large amount of its money in some of these technologies, that they maybe can with some cost sharing with the government.

I assume what you are saying is that the economic incentives are not there to do at this time, based on the risks associated.

Dr. **Kelleher**. The process about which I spoke is some 50 years old. The industry has sought and tried many times to find an alternative, so it does want another process. But even though it appears that we may be on a successful path with our current process, there is no way that my company or any single company could afford to demonstrate that at the level necessary.

Hence, we are, at least at this point in time, hoping to put together a consortium consisting of private companies and industry and the DOE to try to get it to the step necessary where it would be adopted, because the benefit of that technology in the aggregate is great, but to any single company, it is not nearly big enough.

Mr. **Fuqua**. Thank you.

Mr. Walgren?

Mr. **Walgren**. Thank you, Mr. Chairman.

I would like to underscore my appreciation for the chairman's words of support, particularly for the Keyworth steel initiative, and hope that we can bring something to reality through it, and yet I wish I could strike from the record the feelings that the chairman also expressed at how difficult it would be to add a net $12 million to the situation. Yet I have to appreciate that he is speaking with a very accurate perception of the reality that we face this year.

We want to be supportive, and we want to have a vehicle that does a number of these things, and we will in any way we can. We envision that the Congress will be dealing with specific and, hopefully, comprehensive pieces of proposals that would do the kinds of research the steel industry needs.

I wanted to give you an opportunity to underscore, Dr. Leonard, the degree of cost savings. In your statement, you indicated that you are talking about, in the sheet metal, a $4 million program, you are looking at being able to save between 10 and 20 percent of your actual cost of production.

Dr. **Leonard**. That is correct. That is a major savings, because the steel industry is a major user of energy in this country. Incidentally, the largest single component of cost in making steel today in the United States, despite our high labor cost, is now energy.

If we could make that degree of improvement, that is very significant in our competitive posture against our international competitors, which we realize we will be facing in the long run and must be able to face competitively and without Government subsidy.

So this represents, as I see it, a very small program whose impact in the future could be quite large on our international competitiveness in a basic industry.

Mr. **Walgren**. Apparently, you are, in this budget, with that program—it is a 5-year program in which the Government's yearly contribution is what?

Dr. **Leonard**. Yearly, I don't have that number, but I would assume it is approximately one-fifth of the——

Mr. **Walgren**. Of $32 million?

Dr. **Leonard**. Excuse me just a moment. I am informed that the number is $7 million to $8 million per year.

Mr. **Walgren**. Per year, and the private contribution is relatively small; it is one-fifth of $4 million, so you are in the $500,000 to $700,000 range?

Dr. **Leonard**. That is correct, and once again it is in the form of providing key people to actually do the work here.

Mr. **Walgren**. I have been struck by the international perspective that has been brought with such a much higher average experience of cost sharing in government R&D in our major competitors. As the first gentleman indicated, they are contributing up to 50 percent as a norm in their R&D expenditures. Is that a wrongful characterization of your testimony?

Mr. **Poirier**. Fifty percent is some kind of magic number. In fact you are right. Now, there are some cases where the percentage will come down to 20 percent, 25 percent. Those cases are cases where universities get involved or where the company that is sponsoring the project is in a relatively weak financial situation.

It is also, obviously, the level of risk being involved. There have been cases where, if the government really needs the project, because they feel it is very important for the technology base of that country, they will go down to 20 or 25 percent. Below 20 percent, it becomes very difficult.

The only instances we have seen among those 300 or 400 projects we reviewed are cases where the moneys go entirely to universities, in which case it could go up to maybe 100 percent, with a few exceptions.

Mr. WALGREN. This is where I would like to push you as hard as I possibly can, those people particularly interested in the steel initiative, both here and elsewhere in the industry, to maximize that industry contribution.

Dr. Leonard was before our other subcommittee yesterday and mentioned the legitimacy with which we should view a project where there is a consensus, a very broad and firm consensus, that the work should be done, and yet it seems that that consensus has, elsewhere in the world, been supported by substantially greater private sector support than we are proposing here.

There are those in this Government that want to shoot this work down, and the only defense I know for the work is if we have literally the maximum contribution. I know that I am going to be asked by others who will say, Well, you know, for goodness sake, you have a commitment from that industry that they are to, during the period of voluntary restraint trade agreements, to literally pour all their profits into modernization, and why should I support this project when they are only willing to provide $1.5 million, and even that in the form of already on-board personnel and perhaps built-in costs at that point?

Can I push you stronger on the industry contribution?

Dr. LEONARD. You certainly can push me, and I would be very much with you there, sir. I think the realities we face here in this industry are that because of our current circumstances, the commitment of even this much funding to a project of a long-term, high-risk nature like this represents an act of faith.

Now, as we improve our health, hopefully, certainly then a larger commitment by the industry is very appropriate. It is also appropriate that as the project commences and more likelihood of success evolves, hopefully, at that point the judgment of risk of short-term exposure versus long-term gain will shift.

I would also think it appropriate to recognize here that some of the overseas steel industries are indeed government owned or government subsidized in many ways, so to look at one small piece of government and industry funding like this may be somewhat misleading.

We are, as you know, a nonsupported industry at this point, and we find ourselves, of necessity, having to make these balances between short-term survival and, hopefully, investment also in the future. This is our judgment of what is the best we can hope to do at this time under the current circumstances.

Mr. **Walgren**. I would like to at least ask, off the record, that we pursue some evaluation of what the industry is doing in research so that privately we can weigh this contribution against what the industry is doing in other ways, because I just cannot stress enough that to get a thin dime from this budget in these times, we are going to have to be able to convince very skeptical Members that the private sector here puts the highest priority on what we are asking them to extend the Government dollar toward, and that that priority is reflected by their giving it that priority in the whole range of activities that they are undertaking.

Mr. **Ritter**. Will the gentleman yield?

Mr. **Walgren**. I will be happy to yield.

Mr. **Ritter**. I thank the gentleman.

It seems like we are engaged in a role reversal here, because what I am going to say is probably sounding more like it is coming from the other side than what my colleague from the other side is saying.

But I think we do have to make those justifications, and my colleague from Pennsylvania is correct. But I think we also have to look at a Federal science and technology economy that is putting tens of billions of dollars into other areas of research, many billions of dollars in this very DOE department budget, into areas of research where choices have been made and where we are continuing to move apace.

One has to look not further than the fusion energy research program; one has to not look further than high-energy physics to find that there are massive investments being made.

Now, if the single most important criterion that a project is judged on is the fact that it has nothing to do with the private sector, if that is going to mold our decisions as to what we do with our Federal dollars, I think we are going to have certain segments of the private sector that we will not have anything to do with because they may not be there.

So I think what we need to do here—and when we discuss this with our colleagues and with the Department of Energy, which is certainly a major player in this game, we have to promote the idea, the process of collaboration between the private sector brainpower and the brainpower in the national laboratories as competitive with the ongoing past momentum-driven process that is funneling large amounts of money into an existing research establishment.

I think we have to get to a point where everything that you do different does not come out of new money.

I would like to ask Dr. Leonard just a short question, and that is: What about the competition? You know, there is competition in science; there is competition in technology development as well as right flat out on the market, and what about the competition of the Japanese and the Europeans in this area, and how much do we need to be competitive in this process of technology evolution?

Dr. **Leonard**. Mr. Ritter, from a competitive standpoint, I think we all need to understand with no mistake that we are indeed in a competition race for steel technology. There is no question about that.

The real question is, who will generate that next round of new technology for the next century? The race for the next round of technology for the next decade is pretty well along already, and that is where the steel industry's limited resources are already going.

It really comes down to, are we going to get a start now on that leapfrog technology, to use Mr. Love's phrase, for the next century, because that is what this money represents—a significant fraction, incidentally, of the total research budget for the steel industry as a whole, and a very significant fraction of the total budget for all types of things of the American Iron and Steel Institute.

Mr. **Ritter**. If the gentleman would continue to yield just for a moment, I think it is important to note that this, again, is not just the steel industry. It is a process by which brainpower in the private sector, in industries that need the brainpower that is in the Federal Government, can get together. That is a revolutionary process. The fact is that it is driven—the directions, the management, the creativity is driven, again, as you pointed out, Dr. Leonard, from the bottom up, and that is another thing that I think we have to promote.

Also, the technology is not static. Just because another country is performing one technology at a certain level does not mean that they are forever ahead. I mean, we certainly were way ahead of the game in automobiles at one stage in the 1930's and in the 1950's, and we have a heck of a lot of competition today.

So we have to be setting the seeds into the ground and planting those seeds and nurturing them so that, in that next generation, we can be on top. That is what this program is all about.

I thank the gentleman for yielding.

Mr. **Walgren**. The gentleman raises the presence of that competition. Let me give you, Dr. Leonard, an opportunity to respond to one line of thought that has been raised in this committee, and that is that this Korf process that apparently is developing overseas is a process of direct reduction, and that, supposedly, in various capacities, some kinds of direct reduction have been brought along relatively far abroad.

There are some people that we have to have running with us who are arguing that we are not proposing to leapfrog anything and that in fact, since this kind of thing that is proposed is already being done, we are even being redundant. I would love to give you an opportunity to argue against that view.

Dr. **Leonard**. Thank you, Mr. Walgren.

I think I can explain that in fairly simple terms. Think again of the existing steps in the steelmaking process, beginning with the coke ovens, going from there to the blast furnace, from there to the basic oxygen furnace, from there to hot rolling mills, from there to cold rolling mills and even further finishing processes. That is the long, involved, high-capital process we have today.

This Korf process, or K-R process as it is known, at its best, if it succeeds—and remember, it is only at the pilot stage now—would replace the coke oven and blast furnace steps only. What we are looking for here in terms of true leapfrog technology will be some form of process which goes much further than that.

One leap would be from direct iron ore to liquid steel, not iron, which is where the K-R process leaves off. That is the big distinction. We are looking for finished liquid steel in one step, and the K-

R process as it is today constituted does not do that. So we are indeed looking far beyond that.

Then, to finish the thought, the second leap we are looking for is from liquid steel directly to a shape which is very near to that in which the product is finally used. That is indeed also leapfrog technology.

We don't know how to do that today. We have to remember that what we are trying to do here is tap the brains and the resources of our national laboratories to help us find out how to do that. No one has done that yet. So this is our one chance.

Mr. **Ritter**. Would the gentleman yield?

Mr. **Walgren**. I would be happy to yield.

Mr. **Ritter**. In that near final shape casting process, what kind of competition are we facing in that area?

Dr. **Leonard**. Well, all countries of the world are working on that. Of course, we try to keep track of that as best we can. To our knowledge, no one anywhere in the world has yet succeeded in that process, so it clearly is a race there; no question of that.

What we are asking for here is to utilize the real talents of this Nation in making sure that in this race we have good odds of winning, because if we don't, we will find ourselves eventually without a steel industry and, for that matter without a metals industry, because the same kinds of technology capabilities and needs exist in many of our materials industries.

So I see this as a very important juncture for us in deciding what the U.S. future is likely to be in terms of international competition in the materials area.

Mr. **Ritter**. If the gentleman will continue to yield, would you classify all this as high tech?

Dr. **Leonard**. I most certainly would. This is making use of the high-tech capabilities of this country and applying them to our basic industries which so far have not been able to utilize much of that high-tech capability which we have. Here is our chance.

Mr. **Ritter**. I thank the gentleman for yielding, and yield back.

Mr. **Walgren** [as acting chairman]. Well, I hope we can be successful in this area. We lost last year by Presidential veto this automated manufacturing bill which really, in many ways, was very parallel to this and obvious, also, on its face that this was the direction American industry had to go, and the benefits of going that way as rapidly as possible were also very clear.

I guess once burned is twice forewarned, and I can sense from the chairman that we are going to have difficulty. We, on this side of the aisle—although role reversals are always helpful—we, on this side of the aisle—well, no, I cannot speak for others, but I know that oftentimes the argument has been made that, gee, there is a lot of money available that is being spent on this, that, and the other thing, but the difficulty of getting it directed or redirected is very substantial because of the constituency of each program, and I sure would like to succeed on this one, so I would like to see us presenting the most "steelclad" case that we can so that we don't run into some trouble of some kind that we could avoid. I would like the industry to think strongly about how they can represent to the Congress that this really is the maximum contribution that they can make, and relating that to other efforts that they are making in the same area.

I realize that there is lots of demand for research dollars, and I know, for example, that research in product development is probably something the steel industry has to do the most of because that is directly related to your present very direct cash abilities, and I want to see us doing a lot in that area, too—not the Government, but I mean the industry—so that we knew we were conducting a balanced program.

Dr. **Leonard**. Mr. Walgren, may I say that I think you hit on an important point here, because what limited resources the steel industry has are primarily being directed to product development, and that is why we are unable to muster a lot in the way of resources toward this long-range process development application.

Speaking for AISI, we will be happy to supply any additional information and work with you in whatever way it takes to demonstrate that this is indeed a substantial commitment on the part of the industry.

Mr. **Ritter**. If the gentleman would yield just for a moment, I think it is an important point when you talk about product versus process, and I think Dr. Elliott is as aware of this as anyone.

For many, many years, the process technologies—which are basically equivalent to your manufacturing technologies in this particular industry—the process technologies were not sexy items in Government R&D budgets. Again, the steering mechanism was not coming from the industries or the manufacturing entities, the producers. The steering mechanism was coming from inside the Federal Government with the high priests of science making a lot of decisions about engineering, and engineering, to some extent, turning into engineering science.

That is one of the reasons why we are just now getting back to programs at universities in manufacturing science. It is really 20 years too late, though I am glad we are doing it now, but the Federal investments and the Federal R&D economy were not driven or motivated by the needs of American industry, world markets, industrial competitiveness.

Some areas that are not your absolute cutting-edge areas which have taken a lot from the defense R&D and space R&D investments are really hurting in these world markets today.

I thank the gentleman and yield back to him.

Mr. **Walgren**. Let me raise another reservation, and it is not a—I don't mean to be withholding because my purpose is to be really supportive of this, and I intend to demonstrate that. But the arguments that we run into are things like, how can you spend $14 million in the first year? You are starting out essentially from zero, so that if it takes you through the year to develop, that means you are really committing at the rate of $28 million at the end of the year, or some fraction thereof.

I think that there is willingness to do something, but the need to have it so completely grounded in a truly defensible program and understood as such, there remains skepticism among members whose support we must have, that we can properly go at that rate.

Could I ask you, perhaps in another forum, to at least sketch out the details of how we spend that $14 million and at what rates, with the ultimate question that the chairman asked, is there anything less than $14 million that would be constructively allocated in the first year? It may be that it should build and we could get support for building the rate before we would be able to get support for starting out at a flat rate for 2 years.

Dr. **Leonard**. Yes, I understand, Mr. Walgren.

I would say, first of all, that there is a detailed work program already in place—which, incidentally, has been entered into the record here—and that that represents a commitment of certain named scientists at the national laboratories who are today ready to begin work on this.

So this is not something that might get planned and might grow and so on. Rather, it is something that has already been planned in detail, put in place, ready to go at what we judge to be the correct level.

Now, of course, it is always possible to pare programs. I would not be unrealistic to not say that, and anything we do is better than nothing, because what we are really asking is access to the talent of our national treasure laboratories. That is the way I choose to look at them.

So we are perfectly willing to work with you on that. I simply want to underscore, though, that there has been a great deal of preparatory work already done here, and the detail already exists. So, perhaps under some other forum, it might be appropriate to examine that in detail so we can make a better assessment of whether or not this is an appropriate minimum package.

Mr. **Walgren**. Well, I know that we on the committee will certainly be trying to—we will be talking with you in great detail in hopes of finding a way to be successful in supporting these efforts.

Coming from a steel constituency myself, nothing is more important to my community and, I deeply believe, the national interest in that sense. So we certainly do want to be working with you to find a way forward here.

Well, thank you very much. I am sorry to be so focused on steel, folks, but it is very much a large part of my own community's interests, and so I don't want my lack of pursuit of the other witnesses to indicate anything the less of their testimony.

In the absence of the chairman, I want to thank you all very much for your contributions to the committee record. As you know, these are public documents that, when the record is made, are circulated to the widest degree, and you will find people that you have never met or may never see commenting on the views that you have expressed, and we appreciate it as background so that we can be on firm ground with the public's money. Your contribution is a great help in helping us to try to do that.

So, on behalf of the committee, thank you very much for your time and effort and testimony.

The subcommittee stands adjourned.

[Whereupon, at 4:54 p.m., the subcommittee recessed, to reconvene at the call of the Chair.]

[Questions and answers for the record follow:]

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May 29, 1985

Ms. Tina Van Sickle
Committee on Science and Technology
U.S. House of Representatives
Suite 2321
Rayburn House Office Building
Washington, DC 20515

Dear Ms. Van Sickle:

Enclosed please find my reply to your last request dated April 30, 1985 concerning three additional questions that members of the Subcommittee want me to answer (see enclosed copy). As we discussed on the telephone, I already answered questions 1 and 2 during my March 7, 1985 testimony. I therefore addressed only question 3 in my reply.

I will be traveling in Europe for the next 3 weeks, this time to conduct a survey of R&D tribology activities in the Federal Republic of Germany and the United Kingdom. Tribology, the science of wear and tear, has significant impacts on energy conservation and will definitely have more and more importance. Here again, the Europeans are making strong headway in developing new techniques. I believe that this will be a very interesting assignment.

Thank you again for the opportunity that I had to cooperate with the House Subcommittee on Science and Technology. If you have any other questions, please do not hesitate to call me.

Sincerely,

Jean-Louis Poirier /cbt

Jean-Louis Poirier
Manager

Enclosures

3. Your statement mentions that U.S. industrial equipment markets have become vulnerable to replacement by foreign made equipment. To what extent is this situation driven by current exchange rates for the dollar, versus technical superiority of foreign equipment?

This is a very difficult question to answer because there is not, to my knowledge, any definite statistical evidence pointing to which factor is more important, or the relative weights of both factors. However, it is important to realize that a strong dollar really has two effects: it not only makes foreign imports cheaper, but it also makes the price of imported oil in Europe (generally denominated in dollars) much higher. Some European countries were forced to pay up to 50 percent more for their oil in 1984 as compared with the price they had to pay in 1981; in comparison, oil prices in the United States dropped by 17 percent during that same period.

That second effect has caused European countries to increase their pursuit of industrial energy conservation; this, in turn, results in increased RD&D, higher technological innovation, and increased technical superiority. Because a high dollar has this double effect -- creating the motivation to generate new products and making these products cheaper to the U.S. market -- it appears to me that the present currency exchange situation is a double reason to worry about this broadening techology gap in industrial energy conservation between Europe and the United States.

Hearing Questions - March 7, 1985

Mr. Jean-Louis Poirier

1. In your prepared remarks, you have noted (p.19) that European firms are focussing R&D on heat exchangers, cogeneration, process controls, and fluidized bed boilers. Given the focus of European activity, are the DOE Industrial Programs R&D activities focussed on an appropriate mix of technologies to assure that the U.S. will remain competitive?

2. You have recommended greater involvement of the private sector in the Department of Energy's Industrial Programs. How might such an involvement be structured? How would any such proposed arrangement differ from activities currently conducted by DOE?

3. Your statement mentions that U.S. industrial equipment markets have become vulnerable to replacement by foreign made equipment. To what extent is this situation driven by current exchange rates for the dollar, versus technical superiority of foreign equipment?

[illegible]

Edward G. Kelleher
Director, Energy and Process Engineering
and Analytical Services

Champion
Champion International Corporation

May 13, 1985

The Honorable Don Fuqua
U.S. House of Representatives
Committee on Science and Technology
Suite 2321 Rayburn House Office Bldg.
Washington, DC 20515

Dear Mr. Fuqua:

Responses to the questions submitted regarding my Subcommittee on Energy Development and Applications testimony of March 7, 1985, are attached.

Please do not hesitate to contact me should you need additional information.

Sincerely,

Edward G. Kelleher

Edward G. Kelleher

EGK:lh
Attachment

1. Your statement (p. 2) indicates that the paper industry is the number one user of fuel oil among manufacturing industries. Please describe the effect of lower energy prices on industry interest in conducting energy conservation R&D.

The paper industry has been through several bad economic years during which all capital expenditures, including expenditures for energy conservation, have been severely curtailed. The situation has been especially bad for those segments of the industry that produce what may be called commodity grades such as kraft paper and board. Lower energy prices are aiding the recovery, but also are reducing the incentive for energy conservation expenditures as paper companies review extensive lists of deferred projects of all types. Energy conservation R&D, which must compete for available R&D funds with all other R&D efforts, is affected adversely by lower energy prices.

2. Now that the economy is experiencing growth, is there still a need for federal funding of new process technologies? Why?

In order for new process technologies to be accepted in the paper industry, they must be demonstrated on a large scale. This is because the paper process is a highly integrated process wherein a shutdown of part of the process almost certainly means a shutdown of the whole process. Availabilities in excess of 96% are required. Hence, process technology development and demonstration costs are high, often higher than reasonably can be afforded by a single company even though, in the case of an energy conservation technology, it can result in a significant reduction in imported fuels. Our efforts in black liquor gasification are a good example of high risk energy research with high development costs that would not be anywhere near its present state of development were it not for DOE's participation. For these reasons, it is essential that there be continued federal participation in the demonstration of new process technologies if such technologies ever are to be adopted.

Inland Steel Company
Indiana Harbor Works
3210 Watling Street
East Chicago, Indiana 46312

219 392 5820

Norman A. Robins
Vice President
Technological Assessment

Inland Steel

May 14, 1985

The Honorable Don Fuqua
U. S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, D.C. 20515

Dear Mr. Fuqua:

Dr. James H. Leonard, Vice President for Technology, Bethlehem Steel Corporation, forwarded to me your letter of April 30, 1985, requesting answers to a series of questions raised by Members of your Subcommittee as a result of Dr. Leonard's testimony before the Subcommittee on March 7, 1985. Please find attached our answers to these questions.

We would be pleased to provide any additional information that you or the Members of your Subcommittee would wish to have.

Sincerely,

Norman A. Robins
Chairman
Steering Committee of Federal
  Laboratory/Steel Industry Initiative

NAR/kk
Attachment

cc: Dr. J. H. Leonard

Answers to Questions Concerning the Federal Laboratory/Steel Industry Initiative
(Letter to J. H. Leonard from Rep. Don Fuqua, 4/30/85)

1. Question: In your testimony, you request the Subcommittee consider authorizing DOE funding for the "Keyworth" Initiative in FY 1986 for research related to 1) direct production of liquid steel from iron ore, and 2) casting of near net shape solids. Since there have been recent successful tests in direct reduction processes using the "Korf" process, to what extent would the proposed Initiative be redundant?

   Answer: Current large-scale technology for producing steel from iron ore involves two steps: 1) the reduction of iron ore to molten iron in a blast furnace, and 2) the production of steel from molten iron and scrap in a basic oxygen furnace. The "Korf" process, and all other direct reduction processes, produce iron, not steel; thus, they would replace only the blast furnace. The ultimate objective of the proposed initiative is the direct production of steel from domestic raw materials in one step, thus "leapfrogging" both current technology and the new direct reduction technology. Therefore, there is no redundance between the proposed initiative and development of the "Korf" process. On the other hand, one of the early efforts in the proposed initiative will be to evaluate all significant current efforts in direct reduction to see what aspects of these processes, if any, might be suitable as the basis of a direct steelmaking process.

2. Question: The Federal Laboratory-Steel Industry Initiative states (p.12) that, "While a number of direct [iron and steel making] technologies have reached the pilot plant stage and (outside the U.S.) even limited commercial development, none has proven to be both technically and economically viable for the domestic industry."

   If these technologies are already reaching commercialization outside the U.S., to what extent are we going to "leapfrog" our competition?

   What cost performance goals are appropriate, given the foreign activity taking place in direct reduction to steel?

   Answer: The quoted statement was slightly confusing in that, in fact, no "direct steelmaking" processes have ever reached even a significant pilot plant stage; only a few "direct ironmaking" (i.e., direct reduction) processes have reached commercialization, and these have all been based on using natural gas.

   As discussed above, the ultimate objective of the proposed initiative is the direct production of liquid steel from domestic raw materials in one step, thus "leapfrogging" the competition.

   The economics of any ironmaking/steelmaking process are heavily dependent on the availability and price of the raw materials that are utilized in the process. These factors are very site specific, in that a low-cost process in Japan or elsewhere may not be a low-cost process in the United States. Many of the new ironmaking processes that are being developed outside the United States are very much oriented to the conditions that exist in the country of origin but not in the United States. Some of their limitation are:

a) Inefficient utilization of coal energy,

b) Low productivity and thus high capital and operating costs, and

c) Multiple-stage processing.

The Federal Laboratory/Steel Industry Initiative will incorporate the best-available technology on a worldwide basis to develop an ironmaking/steelmaking process that considers the specific conditions that exist in the United States.

Our cost-performance goals are a 50% decrease in capital costs and a 30% decrease in operating costs. These goals are appropriate, given the status of current technology and other developments in progress.

3. Question: The Federal Laboratory-Steel Industry Initiative states (p.3) that a "second objective...is to investigate the feasibility of more innovative long term direct iron and steel making technologies." These innovative technologies may be commercially viable in 20 years as compared to the proposed process for the direct carbo-thermal reduction of iron ore to steel that would be commercially available in 15 years.

   Given the apparent success of foreign activities in direct reduction to steel to date, and the relatively short difference in commercialization lead times (5 years), would it be better to focus research effort and dollars on the longer term options? Please explain.

   Answer: The 15 and 20-year time spans were meant only to distinguish between mid-term and long-term technologies. The mid-term technologies to be developed are intended to be usable commercially within about 15 years, and, more likely, within about 10 years. These mid-term technologies will be extensions of existing processes and concepts, and are considered to have a reasonable probability of success. The "innovative long-term technology" is conceptual only; until some exploratory research is undertaken which would lead to "proof of concept", timing is unknown, but not likely to be less than 20 years.

   The American steel industry cannot utilize existing ironmaking and steelmaking processes over the next 20 to 30 years and remain competitive with foreign producers. Replacement of existing processes must occur during the next 5 to 15 years to be of significant benefit to domestic producers. Thus, both steps are necessary.

4. Question: The tasks outlined in The Federal Laboratory-Steel Industry Initiative call for significant simulation, modeling and code verification capabilities. To what extent is this capability now available?

   How realistic is the schedule for conducting simulation work, given the complexity of the process? What impact would delay in simulation activities have on the overall project?

Answer: Extensive capability exists at Argonne National Laboratory in the development and application of systems analysis code to a variety of energy technologies and chemical process systems. In the modeling work described in the work plan, an existing systems analysis master code developed at Argonne will be utilized, and the appropriate thermochemical computer models for evaluating alternative ironmaking or steelmaking processes will be provided by the steel industry. Although these models do not simulate all physical and economic phenomena, such as the influence of ore mineralogy on physical performance in a furnace, they will provide a proper interpretation during the evaluation procedure. Therefore, we believe that modeling capabilities are sufficient for conducting the initial phase of the Task A work plan.

We consider it feasible to complete the scoping studies for this project within one year; however, realistically, the modeling work would continue into the second fiscal year.

A delay in simulation activities interrupts a smooth and confident transition through the development phases. However, although process simulation is perceived to be helpful in guiding the research program, it is not the only approach to be used.

5. Question: The Federal Laboratory-Steel Industry Initiative (p.27) notes that proposed work beyond FY 85 depends on results obtained in the first year of the program. Assuming success, what level of funding would be required to complete the project? Of this amount, what level of federal funding would be required?

   Answer: Given the funding situation since the proposal was written, the first year of the program will now be FY 86, although some work is proceeding now on a very limited basis. The work plan for the FL/SI Initiative actually covers a two-year period of time, and a funding level of $10 million from DOE each year and $2.5 million from NBS each year is needed to complete that work plan. Once the first two years have been completed, the process development requirements will be more accurately defined, and only the most promising directions for work would continue to warrant attention. The future cost of such efforts will depend on the scope of the efforts. Most likely, "units" of proposed processes will need to be tested on a larger scale than in the laboratory, and the cost of such testing could vary widely -- possibly up to $50 million for some "units". The requirement for federal funding would probably depend on the perception of risk in such testing, and on the state of the steel industry at that time.

6. Question: The Federal Laboratory-Steel Industry Initiative identifies (p.3) a work plan for near net shape casting using electromagnetic fields as applied to the continuous casting of steel which is expected to achieve superior product with minimal energy costs. How much energy will be saved from the adoption of this technology?

   Answer: The development of near net shape casting using electromagnetic techniques will reduce or eliminate the energy associated with slab reheat furnaces and hot strip mills. A United States Steel study showed that the elimination of all hot rolling by the use of a casting process to directly cast hot-band gages (about 0.1 inch thick) would generate a major energy saving of about 5-million BTU/ton. This energy saving is also expected to be representative of the EMC process under consideration as electromagnetic energy usage is expected to be low (under 0.1 million BTU/ton).

7. Question: The Department of Energy's (DOE) industrial program is currently investigating a process of thin strip casting that employs electromagnetic fields in the casting process. To what degree is it premature to initiate activities identified in the "Keyworth" proposal on near net shape casting until the results of the DOE program are completed?

   Answer: The Department of Energy's Office of Industrial Programs is currently funding two new casting process developments. One (U.S.Steel/Bethlehem Steel) is judged near term (commercial in five years) and is aimed at casting about 1-inch-thick sections, which will still require some hot rolling. The other (Westinghouse/Armco) is judged long term and is aimed at casting about 0.1-inch-thick strip. Each of these programs uses a thermomechanical casting system (U.S.Steel/Bethlehem - twin moving belts; Westhinghouse/Armco - single rotating roll) which physically contacts the solidifying steel. Both processes may make some use of electromagnetic fields as a specific enhancement to improve the process (e.g., to control the feeding of liquid steel into the mold, or to improve the strip-roll contact and, hence, improve heat transfer), but neither development is in any way an "electromagnetic casting (EMC) process". In this FL/SI Initiative, electromagnetic fields are used to contain and shape the liquid metal prior to and during solidification and to levitate it without contacting a mold. This is new and novel for thin strip, and offers the potential for significant quality gains over any process in which the strip is physically contacted during solidification.

8. Question: To what extent will universities be involved in the steel industry initiative?

   Answer: Representatives from universities have been involved in planning this Federal Laboratory/Steel Industry Initiative from the very beginning as members of the several Task Groups to identify leapfrog technologies. Also, the universities are substantially represented by membership on the Tasks A and B Program Advisory Committees. Program plans are based on utilizing the expertise residing at the universities as consultants in every phase of the Initiative, and where appropriate, to involve the universities as subcontractors in specific areas of research. Also, participation will be encouraged through the several Faculty Research Programs at the Laboratories.

9. Question: The task for electromagnetic technology for casting processes identified in The Federal Laboratory-Steel Industry Initiative (p.34) identifies the design, construction and operation of laboratory-scale test facilities. Further, if successful, this activity will be followed by initiation of a pilot plant program to demonstrate scale up in FY 1987/88. Assuming success in the early lab scale test, what is the toal cost expected to reach completion of pilot plant demonstration? What level of outyear funding would be required of DOE in the pilot plant demonstration?

Answer: The task for developing the electromagnetic technology for the continuous casting process consists of three major phases:

1) Feasibility studies/proof-of-concept experimentation,

2) Laboratory-scale process development unit to demonstrate the technical and engineering feasibility for electromagnetic continuous casting, and

3) Pilot plant demonstration of the electromagnetic continuous casting process.

The FY 1987/88 starting date for the pilot plant phase was based on a beginning-of-FY-1985 start at full funding for this task. Assuming a FY 1986 start at full funding, the pilot plant phase would be initiated in FY 1988/89; construction would start in FY 1989/90. The technical and engineering data from phases 1 and 2 are essential for making an accurate assessment for the cost of the pilot plant facility. A best guess at this time is a total cost of $20-30 million for the pilot plant, which includes the electromagnetic caster, melt preparation and handling equipment, and limited product processing facilities. The cost of operating the pilot plant is estimated at $6-10 million/year over approximately a three-year period. The estimated cost for Task B--Liquid Steel to Near-Net-Shape -- up to the start of the pilot plant construction is about $25-30 million. Thus, the total cost to complete pilot plant demonstration could range from $60-90 million, over a period of perhaps 8 years. As discussed in Item 5, the requirement for federal funding would probably depend on the perception of risk in the program, and on the state of the steel industry at that time.

10. Question: The Federal Laboratory-Steel Industry Initiative states (p.36) that, "Automated processing of near net shapes cannot be carried out without on-line monitoring of key process variables." To what extent are these special sensors required to monitor process variables under development? What is a realistic time frame for sensor technology to be availiable for use in any laboratory or pilot test demonstration program? To what degree is it premature to start the near net shape initiative without certainty regarding the sensor technology?

Answer: The important word in the quoted sentence is "automated". Without the availability of all of the required sensors, full automation of the final process may not be possible. However, preliminary analysis indicates that the base technology is available for the development of the required sensors and controllers. The major effort will be to adapt this existing technology to the specific requirements of this process. Most of the testing and optimization of sensors/controllers will be done in the laboratory-scale casting unit. Further optimization and development of additional sensors/controllers (if needed) will be done in the pilot plant facility. The program plan is structured so that the required sensors/controllers will be available for the laboratory facility. Because the base technology for anticipated sensors exists, the adaptation of this technology to the development of specific sensors is not expected to impede the timing of this Initiative.

On the other hand, the critical-path step is the development of the electromagnetic casting (EMC) process itself--not the development of sensors. The EMC process development is judged to be of higher risk and of longer duration than the associated sensor developments. Thus, the EMC process development must start immediately, with sensor development in a supporting role. Even if only partial success is achieved in EMC sensor development, the EMC process could still be operated, although quality may not always be controlled at the highest level, or total automation may not be fully achievable. Such a sub-optimum EMC process would still be a significant commercial advance, though savings and applications might be more limited than the total objective.

11. Question: During the hearing on March 7, 1985, there was interest raised by Committee members regarding the industry contribution to the Steel Initiative. Concern was cited regarding the need to demonstrate that the proposal reflected the maximum contribution industry could make, and relating that to other efforts industry was undertaking. You mentioned that you would be happy to supply additional information to demonstrate that the proposal reflected a substantial commitment on the part of the industry. Please provide any additional information that would be helpful in this regard.

Answer: The appended letter describes the substantial contribution by the steel industry to this initiative. A very important factor, only alluded to in the letter, is that the commitment of 15 highly competent people who could otherwise be making valuable contributions to their companies' well-being is a cost to the industry significantly greater than the $1.5 million direct cost of the people involved.

Attachment

Inland Steel Company
Indiana Harbor Works
3210 Watling Street
East Chicago, Indiana 46312

219 392 5820

Norman A. Robins
Vice President
Technological Assessment

Inland Steel

Appendix I

March 15, 1985

Mr. D. M. Anderson
Corporate Director, Environmental Affairs
Bethlehem Steel Corporation
Martin Tower - Room 698
Bethlehem, Pennsylvania 18016

Dear Dave:

At your request, I have surveyed several of the steel company participants to develop an estimate of the likely industry contribution to the Steel Industry/National Laboratories Initiative, over and above the already defined $1.5 million for 15 scientists. The total estimate is $1,350,000 broken down as follows:

$275,000	Industry executive and supervisory personnel involvement in Steering Committees, Program Advisory Committees, special workshops, overall project management, and interaction with the Federal Government.
$675,000	Additional costs generated by participating scientists, including difference between true cost and $100,000, laboratory supervision, living and travel expenses, and corollary technical work generated in industry laboratories.
$400,000	Value of proprietary technology being contributed to the program by individual companies.
$1,350,000	TOTAL

I believe that this number is a good estimate. I think that the total industry participation of $2.85 million, including 15 top scientists, to a program of advanced, or "leapfrog", technology development, at a time when the industry is under great economic pressure that tends to compel a short-term viewpoint, indicates the strong industry commitment to the future of steelmaking in this country, and justifies Federal Government support of the full program.

Very truly yours,

Norman A. Robins

NAR/kk

cc: D. Blair - Bethlehem
J. Leonard - Bethlehem
W. Dennis - AISI

Hearing Questions - March 7, 198

Dr. John F. Elliott

Response to Questions Posed:

1. Question 1 (Concerning The Casting Programs).

If there is a balance of research, development and engineering for each of the three concepts; thin slab, thin stip and near net shape casting, the three programs should proceed with a reasonable possibility of success for each. Each of the programs should include some well focused research on basic problems that are relevant to that concept, but the results should also be applicable to the next generation of casting processes, the nature of which is perceived only dimly today. I am acquainted only with one of the programs so I cannot comment on the balance of effort among the programs. It would seem appropriate that there should be good communication amoung the groups guiding the three programs to ensure (a) that each program includes some investigations regarding important and relevant fundamental phenomena, and (b) that these efforts are coordinated so that there is a balance in the overall effort, and that unecessary duplication be avoided.

In my testimony, I expressed concern that there is a danger in the longer term that the industry will fail to maintain a competitive technological base. Each development program which has specific technological goals should also have a component of fundamental effort to improve our understanding of the science and engineering of solidification and casting processes related to that program, and which, in addition, will provide continuing support for advancing the technological base of the industry in the longer term.

2. Question 2 (Contribution to the technological base)

My response to question 1 relates to casting methods. However, the same point should be made regarding all steps employed in the production and processing of steels. The basic studies of one decade should provide information and understanding that helps to underwrite the technological advances of succeeding decades. The loss of research and development personnel and the serious decline in research and development activities in the steel industry will make it difficult for the companies either to advance the technology or to utilize effectively technology that may be acquired from outside the industry or from foreign sources. Parallel with the decline in research and development in the industry, there is also a serious decline in American universities of support of research related to the science and technology associated with the primary production of steel, e.g. reduction, smelting, refining, casting. These are areas of the technology where the capital investment is large and where most of the energy required in the production of steel is consumed. Thus, not only has the initiative in advancing the technology being passed by the industry to other countries, but also the long-standing leadership of the US academic comunity in scientific research related to primary processing of steels is in danger of being lost to other countries as well. To respond directly to the question, there is need to revitalize the fundamental and applied research programs in industrial and academic institutions. Those responsible for these programs should be expected to strike out in new and innovative ways, and to make use of new methods and advanced scientific concepts from other fields rather than continue to pursue only the familiar problems associated with the current technology.

There is the danger that many people will view the research efforts supported by the "Initiative" as meeting the needs for advancing the technological base of the steel industry. Two important elements of the technology are being considered, and these are important elements. However, the long term need for attention to other important parts of the techological base are now left almost untended in industrial and government laboratories and in academic institutions.

The longer term need for a strong technological base for the industry requires that there be well balanced research activities focused on the generic problems in the important areas of the technology. The research should have continuity, and it should have a mix of participation by industrial, government and academic laboratories. The strength of the technological base depends very much on there being available well trained scientists and engineers with backgroungs that make it possible for them to conduct research effectively. Thus research programs that involve graduate students in academic institutions is an important part of the overall program.

3. Question 3 (Plannning the programs of the Initiative)

As noted above, the Initiative addresses two important area of technology, but these are only two of a number of ares that should have attention in the years ahead. Work on these two ares should proceed, but attention should also be directed to other area of the technology. One might ask the question as to whether it might be possible to produce pure solid iron directly without too large a consumption of energy and also to avoid the need for large and expensive processing equipment. The product would be very different from that which is made by the traditional practice of smelting and refining liquid steel followed by post-refining and then casting the liquid metal into bars, sheets, etc. A whole new array of methods for processing the solid steel into useful products then might be possible. I am not proposing a program on this mythical technology, but I would like to make the point that in some manner research on generic scientific and technical issues that can can provide the base for innovative developments in the years ahead should be in progress in some laboratories.

There is some concern that planning for the program on direct steelmaking under Task A has been delayed. The recent serious reductions in force and changes in assignments in the staffs of the industrial laboratories has delayed the development of a well defined program of work for this task. It is my belief that no experimental investigations should be undertaken until tasks, schedules and staffing assignments are spelled out. Some work on computer modeling is in progress because of availability of people at Argonne National Laboratories, and there are computer codes from several industrial firms that may be applicable to the work of Task A. However, the advances in the technology will not come from running computer simulations alone. The development of concepts, scientific facts, technical systems and processes must be brought along as the computer work proceeds. It is my view that the ratio of the weight of investment in experomental research to that in modeling should be on the scale of about 10/1.

4. Question 4 (Electromagnetic near net casting)

I am not well enough informed to comment on the planning and work of Task B of the Initiative.

5. Question 5 (Plan for direct reduction*)

The question relates to "direct reduction". However, the efforts of Task A of the Initiative is focused on direct steelmaking. I have had extended discussions with a number of people as part of a program for developing a long-term plan for Task A. It is my understanding that there is a concensus that direct steelmaking is the goal, and by the nature of the problems to be solved in making direct steelmaking possible, the program is long range in character. On the other hand, there are generic problems to be faced in reaching this goal, and the progress made with these generic problems should provide spin-offs as the research proceeds. These spin-offs should be applicable in helping to improve the current technology in a variety of ways. Several generic problems that have been targeted are containment of high-temperature reacting systems, clean-up of very hot off-gases, understanding of the kinetics of gas-particle reactions at very high temperatures, removal of tramp elements (copper, tin, etc.) from various kinds of steel scrap, the nature of processes that occur at interfaces among gases, liguid metal and liquid slags, etc. Work on thses problems have both short and long term value. It is easy to make a list of these generic problems. It is not so easy to select and plan specific experimental programs for each generic problem. And it is essential that the research be matched with the talent that is available and that priorities be assigned for the various research topics. That detailed planning has not yet been started.

*There is the continuing difficulty of getting people to look at long range problems. I firmly believe that the objective of Task A of the Initiative should be long range in character and not the solution of immediate problems of the industry, nor the solution of the problems of the current group of direct reduction processes that are in the pilot stage.

6. Questions 6 and 7 (University Participation)

If one accepts the idea that there are generic problems to be solved that relate both to the target processes of Task A and Task B of the Initiative, then portions of the research will have application to the possible development of the succeeding generation of processes and methods for iron- and steelmaking in the future. Thus far the participation of university personnel in the work of the two Tasks has been advisory in character, and has taken the form of participation in advisory groups and in occasional consultations on specific technical questions.

There are several research groups in academic institutions in the US where there is a high level of competence relative to the programs of the two Tasks of the Initiative. The competence includes capabilities in modeling, carrying out experimental programs of research at an advance level, and an intimate understanding of the nature of the applied sciences such as physico-chemistry, transport processes, sensing and measuring methods, properties of materials, etc. as related to the production of steels.

The leaders of these research groups can, and should, participate in groups or committees that are responsible for planning of research programs, the setting of priorities, and overseeing the research work as the programs progress.

On a selective basis, these groups could also participate in various investigations which are components of the work of the Tasks of the Initiative. Their competense should be brought to bear of the more fundamental parts of the programs, especially on the generic probles of the type mentioned above. This would help to advance our ability to master the problems inherent in the current Task assigments, would also help to build our base of scientific and technical understanding, and would assist to educate and train young people to meet the future technological needs of the industry.

John F. Elliott July 13, 1985

[Additional statements for the record follow:]

Ncat the National Center for Appropriate Technology
815 15th Street, N.W., Suite 627, Washington, D.C. 20005 (202) 347-9193

TESTIMONY

by

Peggy Wheeler
Public Affairs Director

before
Subcommittee on Energy Development and Applications
House Science and Technology Committee

March ~~13~~ 7, 1985

Good morning. My name is Peggy Wheeler. I am the Public Affairs Director for NCAT, the National Center for Appropriate Technology. NCAT is a non-profit, private organization specializing in technology transfer of renewable energy and energy conservation technologies through technical assistance, information dissemination, energy monitoring, and pilot projects. It manages federal, state, and corporate contracts in this regard. NCAT manages the National Appropriate Technology Assistance Service about which I am here today.

This Subcommittee has played a vital role over the last three years in assisting the establishment of a vital new technology transfer program for the public called NATAS, the DOE National Appropriate Technology Assistance Service. NATAS has received authorization levels by this Subcommittee since the FY 1983 bill, including the authorization level of $1.25 million for last year's FY 1985 budget. NATAS received $1.5 million in appropriations for FY 1985. I am here to request the Committee to not only maintain the minimum of $1.5 million, which covers the actual base operating budget for NATAS, but also to include additional funds for publications, monitoring and training, totaling $2.5 million.

NATAS operates as a toll-free service offering tailored information and technical assistance on renewable energy and energy conservation technologies. NATAS has two principal objectives: to help people investigate or implement conservation and renewable energy technologies, and to help innovators solve problems they have commercializing energy saving products and services.

NATAS is organized around four tasks:

--to disseminate appropriate technology information,
--to provide engineering and scientific technical assistance,
--to provide commercialization assistance, and
--to coordinate NATAS with other state and Federal activities.

The toll-free line opened on May 1, 1984. Since that time NATAS has handled 7,151 logged in calls, slightly ahead of schedule for the 10,000 annual level projected. These users of NATAS are comprised of about one-half residential, 22% commercial/industrial, and 12% local, state, and federal government clients. Of these, 3,520 users requested information, 3,282 required engineering/scientific technical assistance, and 349 requested commercialization assistance.

The three most common topics of inquiry are solar thermal energy, energy efficient new building technologies and weatherization technologies. But NATAS requests also cover a broad range of technical questions, including air quality, which seems a strong concern, cogeneration, hydro, biomass, wind, resource recovery, photovoltaics, industrial energy systems. (A list is attached that covers the major areas of technology type, including the number of questions under each type.)

Such information begins to show us where the interests of the public lie, what types of technologies they are using, and what technologies they want to learn more about. This should be helpful to you as policy makers, and, if we can provide more information along these lines, I would be happy to oblige.

Examples of technical engineering assistance NATAS has provided are:

- Prepared information on the use of industrial centrifugal pumps as turbines and recommended contacting the manufacturer for more specific information.
- Supplied information on residential and commercial solar heating systems and included referral to local solar energy associations.
- Provided information on cool tubes and included study of cool tube performance.

Examples of commercialization assistance provided are:

- Provided information on commercial development of a wind farm.
- Critiqued a business plan for a residential energy retrofit business.
- Prepared information on patenting, financing, and recommended sources of technical evaluations for an innovative window weatherization device.

A state-by-state summary of the number of users is included as a second attachment for the Committee's information.

Knowledge of NATAS's availability is spreading on an increasingly rapid basis. In the last two months there has been mention of NATAS in periodicals, newspapers, and on a PBS station. These notices sharply increased the use of the service, actually doubling the intake load, demonstrating the potential use as the program becomes better known.

NATAS requires $1.5 million for its base operation. This includes the computerized data base; the individual response to each of 10,000 calls which are 51% engineering, 43% information, and 6% commercialization; and monthly reports to each State Energy Office, as well as DOE offices.

To maintain the high quality level of responses provided currently by NATAS, a $1.5 million budget must be maintained in FY 1986. DOE requested $1 million for NATAS, but NCAT submits that this budget is too low to maintain current quality, and is primarily a reflection of DOE support for the program.

In addition to the $1.5 million base budget for NATAS, other needs have been revealed during operation of the program. NATAS has been using 13 energy conservation and renewable energy publications of the easy to understand, how-to, variety which had been prepared by NCAT under a previous DOE contract. These publications sometimes service the needs of a user when they want information covered by one of these publications. These publications are distributed by State Energy Offices, NATAS and NCAT as well as by GPO. 240,491 copies had been distributed as of February 15, 1985, and many states are in their third printing of their publication copies. One reference in New Shelter on a "Window Insulation" publication has brought in 700 calls a week to GPO ordering the publication. Another mention of a solar greenhouse publication brought in 3,000 orders to NATAS in three weeks. The interest, and need, for these publications is obvious.

NATAS requests have uncovered a variety of user subject interest areas which could be well-served by production of such publications. Topics include space heating, water heaters, energy conservation in warm climates, small business uses of appropriate technologies, waste to energy technologies, cogeneration, education tools, and ways to commercialize appropriate technology.

To produce such publications, which are not available now, would be useful far beyond the NATAS users. They are a simple way of reaching out to thousand of people in a quick, efficient manner, thereby broadening the reach of NATAS in a cost-effective way. The production of eight such publications would require $500,000, added to the base $1.5 million.

In addition to the base budget of NATAS, $1.5 million, and the $500,000 for a publications arm for NATAS, NCAT has identified two other areas which would improve the NATAS program: technical monitoring and training of DOE personnel on the state, regional and federal level.

Technical monitoring is not currently covered within the NATAS budget. Many of the technologies dealt with by NATAS are the result of innovation by smaller businesses and individuals. These innovations could contribute widely or significantly to energy conservation or renewable energy development but NATAS is unable to provide the evaluation of these projects and ideas necessary to lead to their implementation.

In a similar vein, many products, services, and methods that may be of value to those who call NATAS have not been sufficiently assessed to be used in NATAS references.

Such technical monitoring and evaluation is currently within the scope and capabilities of the NATAS staff, working with other specialists in the individual fields.

The budget for monitoring would serve to begin such a technical evaluation capability. This budget would cover the materials such as testing equipment needed to monitor projects, travel for on-site visits, adjunct and consulting expertise required to address some technologies. The number of projects this budget covers for such monitoring and evaluation work is approximately 60. This would be a mix of complex monitoring and evaluation cases and the simple final testing of already developed products before referral is included in NATAS.

Furthermore, on the training arm, in meeting with personnel from the State/Territory Energy Offices, NATAS received the recommendations that workshop assistance be limited to personnel and/or designees of these offices. It was also recommended that NATAS concentrate on training trainers to maximize savings and facilitate the technology transfer process; those trained would train others in their states. NATAS has been monitoring trends in order to identify areas of interest which would best be satisfied through hands-on workshops.

NATAS plans to conduct ten three-day workshops and to disseminate materials developed for, in and during the workshops to other interested groups. NATAS would cooperate with DOE Operations/Support Offices to select an appropriate "sponsor" or home-site (i.e. the DOE office or a centrally located SEO or weatherization assistance group) for the workshop in each federal region. The workshops would be videotaped and the SEO personnel would be trained in using the videotapes for training purposes.

The budgets for these are $400,000 for technical monitoring and $100,000 for training DOE personnel.

These budget items total up to $2.5 million. I believe that each item is very cost-effective and would improve the NATAS program to the level it should exist at to cover its authority in a quality manner.

Thank you for you time.

"TECHNOLOGY TYPE" SUMMARY FOR NATAS CASES

(May, 1985 — February, 1985)

	TECHNICAL	COMMERCIAL
Earth Sheltered or Underground Buildings	31	3
Electrical Systems for Buildings	8	1
Energy Efficient Construction (New)	339	13
Energy Efficient Construction (Retrofit)	120	15
HVAC/Mechanical Systems for Buildings	158	5
HVAC: Air-to-Air Heat Exchangers	23	0
Passive Solar Buildings	95	1
Passive Solar Greenhouse/Sunspace	90	2
Weatherization Technologies	311	7
Energy Conservation (Buildings)	1,175	47
Biomass Energy Generation	27	4
Biomass: Solid Fuels	147	8
Biomass: Liquid Fuels	38	3
Biomass: Gaseous Fuels	39	3
Fossil Fuel Conversion	37	6
Geothermal Energy	34	3
Hydro Energy Generation	85	6
Photovoltaics	86	10
Solar Thermal Energy	563	48
Wind Energy	124	21
Hydrogen/Fuel Cells	9	0
Energy Generation	1,189	112
Appliances	200	12
Cogeneration or Waste Heat Recovery	51	10
Energy Storage	36	2
Industrial/Commercial Energy Systems	33	13
Lighting	24	6
Recycling or Resource Recovery	49	11
Transportation	15	9
Energy Conservation (Non-Buildings)	409	63
Energy General	272	36
Energy Management	53	14
General Energy	325	50
TOTAL	3,098	272

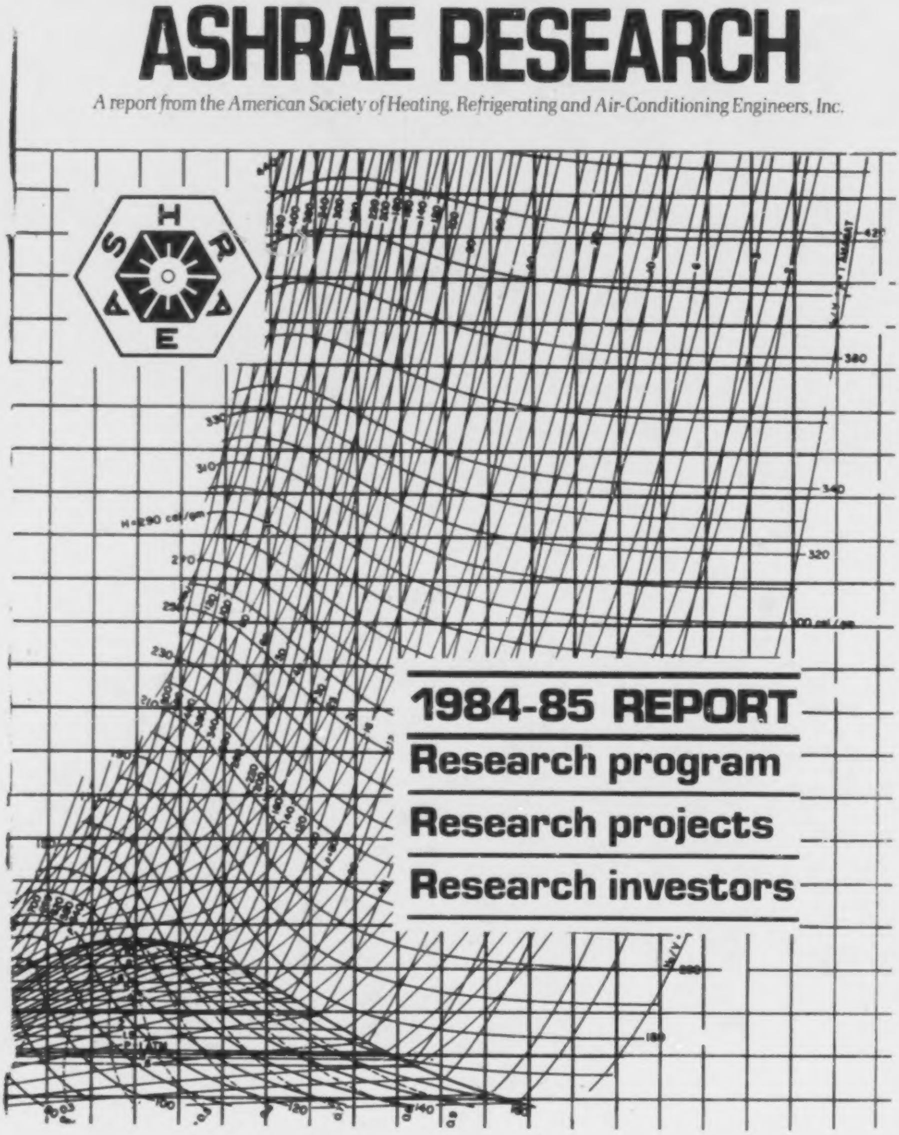
TABLE 5: GEOGRAPHIC DISTRIBUTION OF NATAS USERS

	CUMULATIVE TO DATE				FEB., 1985			
	INFO	TECH	COMM	TOTAL	INFO	TECH	COMM	TOTAL
Connecticut	47	30	4	81	7	5	0	12
Maine	25	26	4	55	9	9	1	19
Massachsetts	100	83	15	198	30	9	2	41
New Hampshire	31	26	3	60	7	4	0	11
Rhode Island	13	11	1	25	2	1	0	3
Vermont	23	33	1	57	10	2	0	12
REGION 1	239	209	28	476	65	30	3	98
New Jersey	83	79	7	169	39	7	0	46
New York	229	198	13	440	109	34	0	143
Puerto Rico	2	3	3	8	0	0	1	1
Virgin Islands	5	5	0	10	0	0	0	0
REGION 2	319	285	23	627	148	41	1	190
Delaware	18	14	2	34	10	4	0	14
Dist. of Col.	74	47	2	123	6	1	0	7
Maryland	68	84	12	164	27	14	0	41
Pennsylvania	258	131	14	403	173	22	2	197
Virginia	135	108	11	254	87	14	0	101
West Virginia	19	17	0	36	11	7	0	18
REGION 3	572	401	41	1014	314	62	2	378
Alabama	36	26	6	68	13	5	0	18
Florida	63	79	17	159	19	9	1	29
Georgia	73	46	1	120	52	9	0	61
Kentucky	41	27	2	70	18	8	0	26
Mississippi	5	10	0	15	3	2	0	5
North Carolina	122	71	9	202	84	11	1	96
South Carolina	30	53	4	87	12	2	0	14
Tennessee	33	33	1	67	2	6	0	8
REGION 4	403	345	40	788	203	52	2	257
Illinois	163	117	9	289	78	17	1	96
Indiana	51	76	4	131	22	15	1	38
Michigan	116	146	16	278	35	29	0	64
Minnesota	332	79	7	418	13	15	0	28
Ohio	102	78	17	197	50	10	1	61
Wisconsin	177	77	5	259	34	20	0	54
REGION 5	941	573	58	1572	232	106	3	341

TABLE 5: GEOGRAPHIC DISTRIBUTION OF NATAS USERS (cont.)

	CUMULATIVE TO DATE				FEB., 1985			
	INFO	TECH	COMM	TOTAL	INFO	TECH	COMM	TOTAL
Arkansas	16	27	6	49	5	6	1	12
Louisiana	21	36	0	57	3	19	0	22
New Mexico	56	30	13	99	4	4	0	8
Oklahoma	25	35	3	63	6	4	1	11
Texas	57	101	13	171	6	21	0	27
REGION 6	175	229	35	439	24	54	2	80
Iowa	33	39	4	76	6	1	0	7
Kansas	34	44	7	85	4	8	0	12
Missouri	81	88	12	181	30	11	0	41
Nebraska	27	42	5	74	2	6	0	8
REGION 7	175	213	28	416	42	26	0	68
Colorado	79	125	19	223	6	8	3	17
Idaho	15	40	4	59	2	2	0	4
Montana	114	212	7	333	11	26	0	37
North Dakota	17	31	1	49	0	4	0	4
South Dakota	8	18	5	31	2	2	0	4
Utah	20	37	4	61	2	5	0	7
Wyoming	13	20	2	35	1	1	0	2
REGION 8	266	483	42	791	24	48	3	75
Arizona	23	31	3	57	4	4	0	8
California	174	254	46	474	9	28	3	40
Hawaii	4	4	2	10	0	0	0	0
Nevada	15	28	2	45	2	3	0	5
Guam	0	1	0	1	0	1	0	1
N. Marianas	0	1	0	1	0	0	0	0
Am. Samoa	0	3	0	3	0	1	0	1
Trust Terr.	0	1	0	1	0	0	0	0
REGION 9	216	323	53	592	15	37	3	55
Alaska	25	22	0	47	3	1	0	4
Oregon	41	56	2	99	7	8	0	15
Washington	98	107	14	219	8	16	0	24
REGION 10	164	185	16	365	18	25	0	43
FOREIGN	8	2	0	10	0	0	0	0

[Appendix: Additional materials for the record follow:]



ASHRAE RESEARCH

A report from the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

1984-85 REPORT

Research program

Research projects

Research investors

Commentary

Richard B. Hayter

AN OBLIGATION IN RESEARCH

A primary strength of ASHRAE is its commitment to research. Thanks to the generous contributions of members and associated industries, ASHRAE's research budget will approach one million dollars during the 1984-85 year. The Society has an obligation to assure that this research will serve the needs of its members and society as a whole. Toward this end, it is necessary to carefully identify research needs and to plan how the resources can be used most effectively.

In 1977 the Board of Directors recognized the need for a coordinated and focused research plan. Although the objective of a plan to assure an effective research program was certainly straightforward, the steps necessary to accomplish that objective were formidable. Between 1979 and 1982 research planning workshops were held with each of ASHRAE'S Technical Committees and Task Groups.

In this first year of the annual planning cycle the committees identified and prioritized approximately 300 research projects.

These priorities became the base by which the R & T Committee began its deliberations for the creation of the long range plan. When completed, the plan will serve as a guide for the development of work statements to be released by ASHRAE as requests for proposals (RFP's). This will result in a greater emphasis on RFP's.

Although the R & T Committee has the responsibility for the development of a long range research plan, the members of the Technical Committees and Task Groups are the core of the planning process. They represent the foundation of our technical expertise and therefore are best qualified to establish research needs and priorities. The plan relies heavily on the annual participation of all the Technical Committees and Task Groups. This major effort by the committees and groups assures that the research plan is dynamic; as is our industry.

For the long range research plan to fully represent the membership, broad participation in its development is necessary. It is not the Technical Committee, Task Group, nor the Research and Technical Committee that creates the plan; the plan is defined by the individuals who serve as volunteers on those committees.

You, as an ASHRAE member, are encouraged to actively participate in the Technical Committees and Task Groups of the Society so that they benefit from your suggestions for future research. Even if it is difficult for you to regularly attend semi-annual meetings of the Society, you can still contribute to the plan by becoming a corresponding member of a Technical Committee or Task Group, by sharing your ideas with local chapter members who serve on the committees, or by completing and returning the questionnaire distributed to chapter members by their chairman.

Richard B. Hayter

Richard B. Hayter
Vice Chairman
Research & Technical Committee

Published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc

ASHRAE RESEARCH

A report from the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

1984-85 REPORT

Strong member support backs projects and grants-in-aid

Research contributions totaled $705,430 during 1983-84 and were made by individuals, chapters, companies and other industry organizations

WILLIAM W. SEATON
Member ASHRAE
Manager of Research

J. RICHARD WRIGHT, P.E.
Member ASHRAE
Director of Technology

ASHRAE utilizes all research contributions received in one year for *projects and grants-in-aid* during the succeeding year. Approximately 25 percent of the research contributions are for $1,000 or more, but the major portion of income is from more modest contributions indicating strong member support.

A demonstration of the strong member support is the fact that 6,850 individuals, companies and organizations made contributions during the 1983-84 Society year.

The efforts of the Research Promotion Committee led by Chairman Damon Gowan collected $705,430 in U.S. dollars. The budget for projects and grants-in-aid for 1984-85 is $960,000. ASHRAE continues to utilize funds from government agencies and cooperates with other groups to jointly fund special projects of mutual benefit. Special projects include accelerated promulgation of standards, technical publications and research.

Research projects

During fiscal year 1983-84 (ending June 30, 1984), ASHRAE initiated 12 new projects and completed 18 projects. The average cost of new projects was approximately $46,000.

Subjects of the new projects ranged from *Improving Flue Loss Methods for Measuring Thermal Performance of Wood Heaters* to the *Effect of Freezing and Frozen Storage on Raw and Further Processed Turkey Products*. Thirteen technical papers based on research projects were presented at Society meetings during the year.

Research projects result either from work statements initiated by the Society's Technical Committees or Task Groups or from unsolicited proposals submitted by any organization interested in conducting research for ASHRAE. Any research related to the Society's mission of advancing the arts and sciences of heating, ventilation, refrigeration, air conditioning or the allied arts and sciences and related human factors is eligible for funding.

Work statements originating from Technical Committees or Task Groups, after approval by the Research and Technical Committee, are offered to prospective bidders for proposals. The bidders' list includes universities and agencies which have a history of cooperative research with ASHRAE or have indicated an interest in ASHRAE research.

Unsolicited proposals are accepted from organizations interested in conducting ASHRAE-related research from self-generated ideas.

Regardless of whether the proposals are solicited from work statements or are unsolicited, the following information should be provided:

1. Precisely what is to be done, by whom, under whose personal supervision, with man hours, materials, instruments and apparatus required, and costs for each.

2. Information regarding the investigator's special expertise, experience, and/or ability which especially qualify him or her for the research proposed.

3. Identified contribution from his organization's resources for the conduct of the project.

Grants-in-aid

Nine grants-in-aid of up to $5,000 were awarded to graduate students who will be conducting research in a field of interest to ASHRAE during the current year. These students and their institutions are:

1. Lynn Rachel Fryer
   University of Colorado at Boulder
2. John David Hall
   Duke University
3. Laura Reimond Kingsley
   Memphis State University
4. Michael W. Larson
   University of Arkansas
5. James F. Osborn
   Carnegie-Mellon University
6. Diane Leslie Owen
   University of Louisville
7. Frank Anthony Stauder
   University of Windsor
8. Jeffrey D. Spitler
   University of Illinois
9. Je-In Yoo
   University of New Mexico

Applications for grants-in-aid should be sent by faculty advisors to the Manager of Research. The applications should state: (1) Student's name, qualifications, his or her need for support, and a copy of the student's transcript; (2) Significance of proposed research; (3) Outline of procedure; (4) Approximate budget; (5) Extent to which institution will support work; (6) Plans for seeking other funds for this or related work; (7) Anticipated plans for publication of research results; (8) Faculty advisor's institution's qualifications.

The latest grants brought the total to $391,532 awarded to 87 students during the 15 years the program has been in effect. Recipients have represented 52 different colleges and universities. The student research programs have resulted in numerous published ASHRAE papers and other reports, mostly theses.

Special projects and tasks

ASHRAE Special Projects and Tasks are cooperative ventures which involve cost sharing between the Society and outside organizations in accordance with the *Policy for Solicitation and Acceptance of ASHRAE Special Projects.* During 1983-84 three new Special Projects and Tasks utilizing $587,044 supplied by outside agencies were initiated, two Special Projects and Tasks were completed, and six initiated in prior years were continued. The fiscal year expenditure for Special Projects and Tasks totaled $590,500, excluding overhead.

J. Richard Wright, Director of Technology, William W. Seaton, Manager of Research, and staff are responsible for soliciting and negotiating Special Project contracts, insuring that traditional Society procedures are preserved. New or pending Special Projects for fiscal year 1984-85 include development of a *Manual of Acceptable Practices for Standard 90,* research related to residential energy conservation, a third thermal envelope conference, and a technology transfer conference. It is anticipated that Special Projects will utilize more than $400,000 supplied by outside agencies and direct expenditures of $374,000.

Research projects for 1984-85

The Board of Directors has approved expenditures for research projects and grants-in-aid totaling $960,000 for FY 84-85. Of the total amount, $667,000 is required for continuing and recently approved projects, leaving $293,000 available for new projects. Competing for the new project funds are 15 proposals and many work statements in various stages of development, plus additional anticipated proposals.

Projects that will be active during the current fiscal year are detailed in this report. Immediately following the title of each project, the expected duration of the project, the agency conducting the research, and the Society Technical Committee or Task Group monitoring the research are indicated. ■

ASHRAE Research 1984-85

221-RP

HEAT TRANSFER AND PRESSURE DROP IN CONDENSING AND EVAPORATING MULTICOMPONENT FLUIDS

December 1980-December 1984
Rensselaer Polytechnic Institute
T.C. 8.5, Liquid-to-Refrigerant Heat Exchangers

Standard compressor design dictates that oil in some quantity will be present as part of the working fluid in any air conditioning or refrigeration system. The purpose of this project is to improve the understanding of such multicomponent two-phase flow. Specifically, the effect of a second nonvolatile liquid component on a condensing and evaporating fluid will be investigated.

The program will concentrate in two areas: (1) two-phase flow pattern studies and (2) pressure drop and heat transfer in forced convection horizontal tube flow with condensation or evaporation. Oil-refrigerant mixtures will be used in these studies in view of their common usage in the refrigeration and air conditioning industry.

298-RP

ANALYSIS OF OPEN SORPTION AND REFRIGERATION HUMIDITY CONTROL SYSTEMS

March 1983-March 1985
Kansas State University
T.C. 3.5, Sorption

Conditioned air is air having specified properties of cleanliness, temperature, and humidity, and its production often requires dehumidification. This may be accomplished using mechanical refrigeration systems or sorption, with aftercooling from natural sources. The choice of dehumidification method(s) is usually based on the specified discharge condition, a specified design condition and the available sources of energy types. Dehumidification equipment will operate for the majority of the time under conditions much less severe than those used for design purposes. However, no systematic procedure for determining the optimum system for routine, day-to-day operation presently exists, regardless of the principle used.

The objective of this project is to develop an analytical method for estimating the annual energy consumption and for determining the cost-effectiveness of alternative humidity-control systems, including refrigeration, open-sorption dehumidification, and combinations of the two. This will result in a procedure which may be used to determine the optimum dehumidification system. Design conditions, climate data, equipment costs, operating costs, and the availability and cost of energy will be inputs to the procedure.

309-RP

DYNAMIC AND SEASONAL PERFORMANCE OF CENTRAL FORCED-WARM-AIR HEATING SYSTEMS INSTALLED IN RESIDENCES

June 1982-March 1986
Battelle Columbus Laboratories
T.C. 6.3, Central Forced Air Heating and Cooling Systems

One objective of this project is to provide a basis for making refinements to the NBS, DOE and ASHRAE test procedures and consensus standards for evaluating seasonal operating efficiency and for the evaluation of energy savings attributable to different central forced-warm-air heating equipment under a wide variety of application conditions. A second objective is to assist industry by providing information in the ASHRAE Handbook in the areas of (a) computation of seasonal system performance for residential forced-warm-air heating systems as a function of significant variables, (b) the selection of appropriate forced-warm-air heating equipment and components for specific applications to achieve energy conserving and cost-effective system design, (c) the sizing of equipment and components for optimum system operating performance and energy use, and (d) the installation and operation of forced-warm-air heating systems for optimum energy savings.

This project is being jointly funded by the Brookhaven National Laboratories (DOE), the Gas Research Institute, and ASHRAE.

315-RP

A STUDY TO EVALUATE ENERGY EFFICIENCY OF ATRIUMS

October 1983-October 1984
W. S. Fleming & Associates, Inc.
T.C. 9.8, Large Building Air Conditioning Applications

The use of atriums in new building construction is very prevalent today. Building developers and owners are being persuaded that atriums are aesthetically pleasing, provide a good environment, and are energy efficient. However, it is the current consensus of the building design industry that more accurate and relevant data are necessary for the proper energy efficient design of atriums and the air conditioning systems serving them.

The objective of this project is to collect accurate and relevant data on both atriums and the air conditioning systems serving them. The data shall include, but not be limited to, existing atrium construction, energy usage, and description of the air conditioning systems serving them, modeled energy efficient atriums developed from the existing atriums through computer modeling, and energy usage comparisons of the existing and modeled atriums with those of the building types in which the atriums were found. A comprehensive literature analysis shall also be employed for the data collection.

321-RP

HVAC SYSTEM DYNAMICS AND ENERGY USE IN AN EXISTING BUILDING

August 1982-November 1984
University of Wisconsin
T.C. 4.6, Building Operations Dynamics

The purpose of this research project is to determine strategies which incorporate building occupant comfort and HVAC system dynamics and interactions which will potentially reduce energy use. These strategies will then be implemented and tested. The strategy development is based on the analysis of data on systems performance presently available or being taken during the execution of the project.

First, a TRNSYS model of the Atlanta IBM building's HVAC system and control system will be developed. Next, the model will be used to evaluate current proposed control strategies and to compare the results of the model prediction with actual results. Finally, the control strategies for energy and economic savings will be evaluated.

336-RP

INFLUENCE OF OIL ON PRESSURE DROP IN REFRIGERANT LINES

September 1983-March 1985
University of Missouri-Rolla
T.C. 10.3, Refrigerant Piping

ASHRAE research project 109-RP as originally funded was to include R502 refrigerant and alkylbenzene lubricants in the experimental work. Due to overruns, the project was closed without testing either R502 or alkylbenzene. Subsequently, a study of suction line pressure drop in an R502 operating system using both a 150 SUS mineral oil (that used in 109-RP testing) and a 150 SUS alkylbenzene oil was made by others with less than satisfactory results.

It is believed that, in order to provide the refrigeration industry with reliable handbook pressure drop data, the pressure drop tests covered by 109-RP should be conducted with other types of oil and R502.

The object of this work is to extend the research conducted under 109-RP, Transport of Oil in Pipes by Refrigerant Vapor, to include the influence of oil/refrigerant solubility on pressure drop and on experimental verification that these correlations apply to R502 refrigerant.

337-RP

MEASUREMENT OF WATER VAPOR MIGRATION AND MOISTURE STORAGE IN COMPOSITE BUILDING CONSTRUCTIONS

March 1983-October 1984
The Manville Corporation
T.C. 4.4, Thermal Insulation and Moisture Retarders
T.C. 9.6, Systems Energy Utilization

The investigation of moisture behavior in building envelope components has much practical importance since it is the condensation or wetting phenomenon that is believed to cause a significant deterioration in the thermal performance of wall insulation. In addition, the presence of liquid water is known to cause physical deterioration of the structure by causing decay, corrosion, and paint failure.

The primary objective of this research program is the development of reliable fundamental data under carefully controlled laboratory conditions on the accumulation of condensed water vapor in a typical insulated light-frame wood residential wall, and the effect of that moisture on thermal performance of the wall. This information is needed for inclusion in the 1985 *ASHRAE Handbook - Fundamentals.*

A secondary objective of this proposal is the development of basic moisture migration data for validation of theoretical models for moisture vapor transfer as applied to a composite residential wall structure.

341-RP

THERMAL CONDUCTIVITY OF LOW AND INTERMEDIATE MOISTURE FOODS

December 1982-December 1984
Texas A & M University
T.C. 11.9, Thermal Properties of Food

Most thermal conductivity work has been done on foods having high moisture content, where water has a predominant influence. This research will advance the state of the art in engineering systems for low and intermediate moisture foods.

The objective of this project is to measure the thermal conductivity of low and intermediate moisture foods such as jams, jellies, and pie fillings; sausage and other comminuted meat products; dried fruits, bakery products, and pet foods.

Some of the factors to be considered are mass density, moisture content and porosity. This work will set the stage for the future development of mathematical models for the prediction of thermal conductivity of similar foods.

344-RP

A STANDARD DEVICE FOR CALIBRATING CALORIMETER TEST ROOMS

September 1982-September 1984
Kansas State University
T.C. 7.5, Room Air Conditioners and Dehumidifiers

An industry-wide standard for calibrating room air conditioner calorimeter rooms does not exist. At present, the only way a manufacturer can check the accuracy of a calorimeter room is by checking his instrumentation against the cooling capacity of a calibrated "standard air conditioner." Once calibrated, this particular air conditioner is used as a secondary standard by the manufacturer. Consequently, if for any reason this "standard air conditioner" becomes damaged in transport, loses charge, or in any way drifts from calibration, the manufacturer may be led to believe his calorimeter room instrumentation has drifted.

The objective of this research project is to develop an accurate calibration system which can be duplicated by individual room air conditioner manufacturers for calibrating calorimeter test rooms. This will include the design, construction, and demonstration of a working device capable of providing a "standard cooling capacity" that can be measured accurately enough at a manufacturer's location to be considered a secondary standard.

This project will cover all phases of the development of a "standard cooling capacity" device, including the development of all the necessary sub-systems to achieve an accurate calibration of a calorimeter test room.

350-RP

EFFECT OF PROCESSING, PACKAGING AND STORAGE ON HIGH-QUALITY SHELF LIFE OF HOT-BONED GROUND BEEF

September 1982-September 1985
University of Maryland
T.C. 11.1, Meat, Fish and Poultry Products

Since the energy crisis of 1974, attention has been directed toward the opportunity of energy-saving methods without serious quality losses during refrigerated and frozen handling and storage of foods. Studies have demonstrated that savings of 20-40 percent in energy consumption can be achieved with minimal losses in storage duration and/or quality level of frozen fruits, vegetables, and a variety of prepared foods. It was also established that substitution of plant proteins (such as textured vegetable proteins) for animal protein did not adversely affect quality or shelf life of the prepared food.

Low temperature handling of red meat is also undergoing substantial changes so that similar information needs to be developed. Approximately 70 percent of fresh beef, for example, is now distributed as boxed primal cuts or boned, diced, or ground beef.

This research project will determine the effects of chilling and freezing rates, packaging, and storage conditions on high-quality storage life of chilled and frozen packaged hot-boned ground beef. Based on this information, the cost/benefits for optimal energy utilization for the desired high-quality shelf life of beef will be calculated.

353-RP

A STUDY TO DETERMINE SUBJECTIVE HUMAN RESPONSE TO LOW LEVEL AIR CURRENTS AND ASYMMETRIC RADIATION AT THE LOWER BOUNDARY OF HUMAN COMFORT

December 1982-December 1984
John B. Pierce Foundation Laboratories
T.C. 2.1, Physiology and Human Environment

Thermal non-uniformities such as drafts, radiant asymmetry and vertical temperature differences in an otherwise thermally comfortable space may cause local discomfort that detracts from the environment.

The objective of this study is to obtain sufficient data on the response of human subjects to drafts and radiant asymmetry on the cold side of the comfort range in order to establish guides on acceptability in that environment. The study will include both men and women under 40 years of age. The study will include a comprehensive literature analysis of recent investigations of responses to low level air currents and radiant asymmetry.

356-RP

REAL TIME DETERMINATION OF CONCENTRATION OF OIL DISSOLVED IN REFRIGERANT FLOW STREAM WITHOUT SAMPLE REMOVAL

April 1984-April 1985
Iowa State University
T.C. 1.2, Instruments and Measurements

The presently accepted method of measuring the concentration of oil dissolved in a refrigerant flow stream requires that a refrigerant sample be physically removed from the operating system. This may disrupt the normal operation of the refrigeration system.

The objective of this research project is to develop a new method of measuring the weight fraction of oil and refrigerant in an operating refrigeration system. This will be accomplished without removing refrigerant samples and without affecting the system operation in any way. Using this new method, oil measuring instruments will also be designed, built, and satisfactorily operated in the laboratory and in the field. Guidelines established by the work statement address the need for a measurement technique which will use the following as criteria for designing and building such an instrument:

Oil concentration range - 0 to 30%; accuracy range - ± 100% at 1% oil, ± 3% at 30% oil; refrigerants - R-12, R-22, R-502 and R-290 (propane); oils - natural petroleums with low and high percentages of aromatic hydrocarbons, synthetic oil; contaminants - waxes, decomposition products of oil, and water.

An important part of the project will be to investigate, by both a literature search and actual measurements, a wide range of properties to determine which properties are most suitable for inferring the concentration of oil.

366-RP

DEVELOPMENT AND PREPARATION OF A DESIGN DATA MANUAL FOR CLOSED-LOOP, GROUND-COUPLED HEAT PUMPS

April 1983-May 1984
Oklahoma State University
T.C. 6.9, Thermal Storage

In areas of 3,000 heating degree days or less, the use of ground-coupled heat pumps appears to be a cost-effective heating/cooling method open to a large number of existing buildings, particularly residences. In cooling, the condenser heat is put back into the ground, which greatly improves air conditioning C.O.P.s and reduces peak demand utility loads. The sales appeal of putting heat back into the ground in summer for use in fall or winter, eliminating the need for a back-up system, and eliminating the unattractive appearance of solar roofs indicates that demand for this product will grow rapidly when made available to the public.

The purpose of this project is to collect and organize data pertinent to design of the ground coupling device from available literature and active projects. It will take into account thermal properties of different soils over a range of moisture levels, pipe depths and spacings, surface water, horizontal and vertical loop alignments, direction of heat flow, heating/cooling load ratio, and climatic variations.

A manual providing data for design of closed-loop, ground-coupled heat pump systems, using the results obtained will be prepared, and additional data needed for the design of these systems will be identified.

370-RP

TRANSPIRATION COEFFICIENTS OF FRUITS AND VEGETABLES IN REFRIGERATED STORAGE

September 1983-September 1986
University of Florida
T.C. 11.5, Fruits, Vegetables and Other Products

The rate of transpiration in fruits and vegetables is one of the main factors that affect quality of the product. Moisture transpires continuously from fruits and vegetables during handling and storage when subjected to a water vapor pressure deficit. Under many conditions, the loss may be great enough to cause the commodity to shrivel, impair the flavor and lower the market quality. The resulting loss in weight not only affects appearance, texture, and flavor but also reduces the salable weight.

The objective of the proposed research is to obtain a body of relevent and accurate data on the transpiration coefficients of fruits and vegetables in order to permit the determination of moisture loss rates of these products during cooling or storage at various levels of temperature and humidity. This work will be carried out in two phases. Phase I will concentrate on the development and demonstration of a satisfactory method for measurement of transpiration coefficients, and Phase II will be devoted to the actual measurements of the coefficients. Coefficients will be measured on products including grapefruit, grapes, lemons, limes, oranges, peaches, strawberries, blueberries, lima beans, snap beans, beets, cabbage, carrots, onions (dry), peppers and tomatoes.

378-RP

AN EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF REFRIGERANT-OIL MIXTURE ON CONDENSATION HEAT TRANSFER COEFFICIENT AND PRESSURE DROP IN WATER-COOLED SHELL AND TUBE CONDENSERS

December 1982-December 1984
Concordia University
T.C. 1.3, Heat Transfer and Fluid Flow

Migration of lubrication oil from the crank case of a compressor into the other components of a refrigeration system is a problem which has a significant effect on the heat transfer from and to the circulating refrigerant. The presence of oil in the refrigerant condensate on the condenser tubes results in variation of thermal properties in comparison with that for pure oil or refrigerant.

The objective of this research is to investigate the mechanism of heat transfer during the condensation of halogenated hydrocarbon refrigerant when mixed with a predetermined amount of a selected lubricant oil using experimental studies.

In this study, the specific effects of oil-refrigerant solutions on the heat transfer and pressure drop in a water-cooled shell and tube condenser will be investigated. Correlations of both condensation heat transfer and pressure drop in the condenser for one completely miscible and two other partially miscible refrigerant-oil mixtures will be developed. These will serve as tools for modifying the design method of the water-cooled refrigerant condenser taking into account the effects of oil.

382-RP

DEVELOPMENT OF HVAC EQUIPMENT COST DATA BASES

October 1983-April 1985
ADM Associates, Inc.
T.C. 1.8, Owning and Operating Costs

Recently, ASHRAE sponsored a research project, 310-RP "Establish Feasibility and Background for an Equipment Maintenance Costs Work Statement," which established that sufficient sources do exist which contain heating, ventilating and air-conditioning (HVAC) equipment maintenance cost data (MCD). The need for these data in establishing objective evaluations of alternative systems over the life of the system and/or its components is evidenced by numerous inquiries received.

The results of 310-RP indicate that many manufacturers, building owners and operators, and consulting engineers are interested and anxious to locate sources of HVAC equipment maintenance costs and that there are many sources in the United States which have available HVAC equipment maintenance cost data in various formats.

The objective of this project is to obtain accurate and relevant data on HVAC equipment/system MCD. The data will be dollars reported spent for HVAC system maintenance for office buildings. This body of data will include buildings where the effects of the type of the HVAC system (reheat, induction, variable air volume, etc.), chiller size, building size (square feet), location and building usage can be identified. A comprehensive analysis of the data will also be performed in order to determine the most reliable format of presentation.

384-RP

VALIDATION OF VARIABLE-BASE DEGREE-DAY METHOD

June 1983-June 1985
University of Colorado
T.C. 4.7, Energy Calculations

One of the simplest and most widely used methods of estimating energy use for heating and cooling in houses is the degree-day method. The recently developed variable-base degree-day method is the same in principle as the standard degree-day measure calculated for a base temperature specific to a building.

The objective of this project is to ascertain the accuracy of the variable-base method in determining the annual heating and cooling energy use as a basis for comparison. Building data suitable for the validation study will be identified and assembled. In a similar manner, weather data suitable for the validation will be identified. These data will use the variable base degree day to calculate the energy use for heating and cooling for the period for which the energy data are available. Finally, the calculated energy use will be compared with the actual energy used to determine the accuracy of the method.

388-RP

VERIFICATION OF STRATIFIED AIR CONDITIONING DESIGN

April 1984-April 1985
Kansas State University
T.C. 9.2, Industrial Air Conditioning

Conventional industrial air conditioning systems use design approaches based upon experience gained in other facilities. This can result in improper equipment selection or oversizing, excessive energy use or inadequate temperature or humidity control in the space. The use of temperature stratification to reduce the cooling load is not well understood.

There has been extensive research toward defining the effect of stratification on industrial air conditioning systems. Unfortunately, there has been almost no confirmation of the research results in a manufacturing situation. Therefore, the information gained from the research generally has not been included in accepted design guidelines and criteria.

The objective of this project is to evaluate the performance of air conditioning systems designed to reduce cooling energy requirements and to develop design guidelines which will tell the designer what influence supply and return locations will have on the air conditioning system performance.

397-RP

THE EFFECT OF INDOOR RELATIVE HUMIDITY ON SURVIVAL OF AIRBORNE MICROORGANISMS AND THE RELATED ABSENTEEISM IN SCHOOLS AND HOSPITALS

April 1983-September 1984
University of Saskatchewan
T.C. 2.1, Physiology and Human Environment

Tests by several different investigators with comparable human test subjects have shown a reduction in either absenteeism or occurrences of the common cold in 75 percent of the studies when the indoor relative humidity was increased during the winter heating season. It has not been possible to establish the cause of the reduction or explain the conflicting results in the remaining tests. Laboratory studies of airborne microorganisms show that their survival time in general is minimal in the 40 to 60 percent rh range.

The objectives of the project are (1) to test the hypothesis that increasing or decreasing the indoor humidity in winter toward 50 percent in cold climates reduces the survival of airborne microorganisms in buildings and (2) to relate the findings to the absentee rates in 12 schools and three hospitals. The studies will continue through the other seasons of the year to create a comparison between absenteeism and survival of airborne organisms in air-conditioned and non air-conditioned buildings.

407-RP

REFRIGERANT PROPERTY TABLES (I-P Units)

July 1983-November 1984
University of Idaho
T.C. 3.1, Refrigerants and Brines

In an earlier ASHRAE project, the thermodynamic property tables and pressure-enthalpy graphs in SI units were prepared for 31 commonly used refrigerants. Subsequently, the decision was made to publish the Handbook of Fundamentals in both IP units and SI units. Therefore, there is a need for thermodynamic property tables and pressure enthalpy graphs in IP units.

This project will prepare these tables and graphs in IP units for use in the 1985 *ASHRAE Handbook - Fundamentals*.

409-RP

ANALYSIS OF THE ENERGY USE AND CONTROL CHARACTERISTICS OF A LARGE VARIABLE SPEED DRIVE CHILLER SYSTEM

September 1984-March 1986
University of Wisconsin-Madison
T.C. 4.6, Building Operations Dynamics

The Central Utilities Plant at the Dallas/Fort Worth Airport is installing a variable speed, electric drive on a 6,000-ton centrifugal chiller. The purpose of this retrofit is to reduce energy costs for cooling. It is apparent that other large variable speed drives for HVAC equipment will become increasingly feasible. Thus, it is necessary to consider the characteristics of such systems. First, how can they be controlled so that the anticipated energy conservation is achieved? Second, what new opportunities for conservation exist due to this more flexible capability?

Matching the drive speed of HVAC equipment such as fans, pumps and centrifugal chillers to the equipment load has been and is of significant interest due to the potential to reduce energy consumption. In most cases, varying the drive speed to meet changing load requirements is more efficient than other forms of modulation.

The objective of this research project is to determine the static and dynamic energy use and control characteristics of the variable speed chiller and the chiller plant at the Dallas/Fort Worth Airport and to analytically represent these characteristics.

The results of this research project will provide a detailed understanding of the static and dynamic characteristics of a large variable speed drive chiller and associated equipment. Based on this information, it will be possible to explore control methods for such equipment, better understand the potential for energy savings, and provide a base for a broader understanding of the application of variable speed drives in HVAC equipment.

411-RP

A COMPREHENSIVE DATA BASE FOR ESTIMATING CLOTHING INSULATION

October 1983-October 1984
Kansas State University
T.C. 2.1, Physiology and Human Environment

Revision of ASHRAE Standard 55-1981 and Chapter 8 of the *ASHRAE Handbook - Fundamentals* should be based on a thorough literature search on clothing insulation, and more importantly, on a synthesis and evaluation of the data. In addition, new information is needed to fill the gaps so that a comprehensive data base on clothing insulation is developed.

The purpose of this study is to expand the current data base of garment insulation (clo) values and revise the methods for use in estimating clothing insulation in ASHRAE Standard 55-1981, "Thermal Environmental Conditions for Human Occupancy." Specific objectives are:

1. To develop a new chart of garment insulation values for use in revising ASHRAE Standard 55-1981 and Chapter 8 of the *ASHRAE Handbook - Fundamentals*.
2. To determine the relationship between fabric insulation and garment insulation for specific designs.
3. To develop regression equations for estimating the clo value of an ensemble from the sum of the clo values of its constituent garments.
4. To re-examine the relationship between f_{cl}, I_{cl} and other clothing variables for all garments and ensembles and for special types.
5. To develop other methods for estimating clothing insulation.

414-RP

INVESTIGATION OF TURBULENCE-PRODUCING INSERTS ON HEAT TRANSFER IN TUBES WITH APPLICATION TO FIRE TUBE BOILERS

September 1984-September 1986
Iowa State University
T.C. 1.3, Heat Transfer and Fluid Flow

The heating and ventilating industry has considerable application for the heating of water by combustion gases flowing inside tubes. Two examples are fire tube boilers for building heating and for service water heating. If the heat transfer process is improved by increasing the convection heat transfer coefficient on the gas side of the tube, the heating surface required in this type of equipment and, therefore the cost, will be reduced. Therefore many manufacturers install turbulence-producing inserts in boiler tubes to increase the heat transfer coefficient.

Several different insert configurations are marketed, almost all of which have been designed by "cut-and-try" methods. As far as is known, none of the insert designs was based on known principles. This research project will correct this situation by meeting these three principal objectives: (1) to obtain data for existing commercial inserts as a means of assessing the state of the art, (2) to reveal details of how and why inserts increase convection coefficients, and (3) to formulate equations for the design of higher performance inserts.

421-RP

THERMAL COMFORT OF THE ELDERLY: EFFECTS OF INDOOR MICROCLIMATE, CLOTHING, ACTIVITY LEVEL AND SOCIOECONOMICS

October 1983-October 1984
State University College at Buffalo
McMaster University
T.C. 2.1, Physiology and Human Environment

During the last two winters many elderly have not maintained the level of thermal comfort in their homes that would be predicted from laboratory studies. Rather, the combination of their poor thermoregulatory responses, blunted perception of temperature change, and the high cost of heating fuels has resulted in an apparent breakdown in the ability of many elderly to maintain proper thermal comfort under real life conditions.

The objective of this study is to conduct a survey to determine the effects of indoor microclimate, clothing and activity level on the thermal comfort of elderly persons of different socioeconomic groups. Using a thermal comfort meter, omnidirectional anemometer, aspirated psychrometer, and infrared thermometer, microclimate of the living space of elderly persons will be measured and these physical measures compared to the subjective responses of these same elderly as determined by a questionnaire. By conducting this survey in a large number of homes chosen to represent different socioeconomic groups, these findings can be related to socioeconomic findings and differences in lifestyles.

423-RP

IMPROVING FLUE LOSS METHODS FOR MEASURING THERMAL PERFORMANCE OF WOOD HEATERS

June 1984-June 1985
OMNI Environmental Services, Inc.
T.C. 6.4, In-Space Convective Heaters

A flue loss method for measuring the heating performance of wood-fired heaters was first proposed in 1979. Results using the method were not fully consistent with direct measurements using a calorimeter room. Reported heat outputs and efficiencies varied by as much as 19 percent. Due to these unusually large variations and possible systematic errors identified by researchers, flue loss methods are not now generally accepted for rating wood heaters.

In the absence of an acceptable flue loss approach, manufacturers must use calorimeter rooms to accurately measure heater performance. Because calorimeter rooms are expensive to build and operate, they are used by only a very few manufacturers to rate wood-fired units.

The objective of this research project is to investigate the flue loss method, determine the sources of error relative to the direct calorimeter method, and develop an accurate flue loss method for use in the industry. An analytical model that will normalize thermal performance parameters such as heat output and efficiency between the direct and indirect methods will be the overall goal of this research effort.

427-RP

DETERMINATION OF VALIDITY OF REFRIGERATOR/FREEZER ENERGY TESTING

September 1984-September 1985
University of Missouri-Kansas City
T.C. 7.1, Residential Refrigerators, Food Freezers, and All Drinking Water Coolers

Domestic refrigerators, refrigerator-freezers and freezers are currently required to carry a Federal Trade Commission label showing average yearly cost of operation. This value is calculated using an estimate of average yearly energy consumption based upon a standard 90°F closed-door DOE test procedure. This test has been used as the industry standard for some years and offers the advantages of simplicity and repeatability. However, the use of the test assumes that elevated ambient temperature alone can be used to simulate the effect of actual home usage, with door openings and food load changes, on energy consumption.

Since test results can potentially influence consumer buying decisions, utility incentive programs, and product design direction, it is important that they do, in fact, accurately reflect energy consumption under usage conditions in the home. Therefore, there is a need to develop additional information concerning the validity of current test procedures and results as a representation of actual product energy usage.

The objective of this project is to obtain accurate and sufficient laboratory and/or field test data to either verify that current energy test methods accurately represent average energy consumption under in-home usage conditions for modern product designs and fairly represent the effects of various design improvements, or furnish a basis for developing improved test procedures.

430-RP

DEVELOPMENT OF RESIDENTIAL HOT WATER USE PATTERNS

April 1984-September 1989
Ontario Hydro Research
T.C. 6.6, Service Water Heating

Domestic water heating represents the second largest use of energy, next to space heating, within residences of North America. For this reason the utility industry and the water heater manufacturers have been increasingly concerned with the suitability of the water heating devices they promote in relation to the needs of consumers.

Over the last decade, the family structure and lifestyle have gone through changes which have altered the household's hot water consumption. Due to variations of family size, number of appliances requiring hot water and hourly distribution of hot water usage, the demand patterns may be subject to wide variation in both magnitude and time distribution.

The main objective of this project is the development of typical residential hot water use patterns. Average hourly, daily and monthly profiles will be made available in tabular and graphical form for various engineering purposes. Concurrently, the average daily hot water usage per household will be established and the effect of various factors such as family size, age and lifestyle, will be analyzed.

The results of this study should be of great assistance in the revision of Chapter 37, "Service Water Heating," of the *ASHRAE Handbook - Systems* as well as to the engineering community involved in the design and development of future water heating systems.

432-RP

EFFECT OF FREEZING AND FROZEN STORAGE ON RAW AND FURTHER PROCESSED TURKEY PRODUCTS

June 1984-June 1986
University of Maryland
T.C. 11.1, Meat, Fish and Poultry Products

The annual per capita consumption of turkey has been predicted to increase significantly by 1990. A substantial amount of this increase will be in further processed products. A major percentage of these further processed products and of raw turkey are maintained in frozen storage. All of these facts indicate more use of freezing and frozen storage facilities in turkey processing and merchandising.

Freezing and frozen storage are major costs in producing turkey and turkey products. These costs are expected to increase as energy becomes increasingly expensive. To remain competitive, the turkey processing industry must become even more efficient than they are at present. One area for increased efficiency is that of freezing and frozen storage.

The objective of this project is to determine the effects of freezing time and frozen storage duration on the chemical, microbiological, physical and sensory quality of raw and further processed frozen turkey products, and to calculate cost/benefit for optimal energy utilization to maintain high-quality turkey products.

440-RP

FUNDING OF NINE (9) SPECTROPHOTOMETERS

June 1984-June 1986
National Oceanographic and Atmospheric Agency
Task Group on Halocarbon Emission

ASHRAE has an interest in a scientific analysis of uncertainties associated with the stratosphere and ozone depletion. Scientists associated with National Oceanic and Atmospheric Administration have developed a research program to measure total column and vertical profile data. Funding is largely from the Environmental Protection Agency, NOAA, and Chemical Manufacturers Association. Recently they found a need to add hand-held spectrophotometers to assist in calibrating the sunphotometers.

The basic purpose of the research is to provide objective measurements of ozone, and to ultimately prove or disprove the theoretical calculations that seemingly threaten the use of halocarbons. The request for ASHRAE funding is to assist the research team in obtaining the spectrophotometers.

442-RP

EFFECT OF TEMPERATURE FLUCTUATION ON TRANSPIRATION AND PHYSIOLOGY OF FRUITS AND VEGETABLES IN REFRIGERATED STORAGE

September 1984-September 1985
The Pennsylvania State University
T.C. 11.5, Fruits, Vegetables and Other Products

Transpiration or moisture loss from fruits and vegetables in refrigerated storage is a major factor involved in loss of salable weight. Little information is available, however, on the effect of fluctuating temperatures on transpiration and physiology of fruits and vegetables. Temperature fluctuations occur in refrigerated storage due to thermostat tolerances. However, this refers to temperature fluctuations in the vicinity of the thermostat only. Temperatures near the fruits and vegetables themselves may vary over different ranges depending on numerous factors such as respiration rate, ventilation rate and relative humidity. The transpiration behavior in such situations is complex.

The objective of the research is to determine the effect of storage temperature fluctuation on transpiration coefficient, respiration rate, microbial activity, fungal growth and senescence disorders. The research study will be limited to three of the following commodities: apples, mushrooms, tomatoes, potatoes.

HONOR ROLL

1983-84 ASHRAE RESEARCH INVESTORS

LISTED ARE THOSE who have made a special investment in ASHRAE Research during the 1983-84 fiscal year, which closed June 30, 1984. These contributions to the research fund were made through a local chapter or directly to Society headquarters.

Contributions from individuals, chapters and industry organizations totaled more than $700,000.

These contributions are the result of enthusiastic, voluntary efforts of Chapter Research Promotion Committees, which contact local organizations and set fund-raising programs within chapter activities, as well as the work of the Society's Research Promotion Committee.

Special recognition is extended to companies which permitted employees to solicit research funds during company business hours. To each company, THANK YOU for this invaluable contribution.

This Honor Roll of 1983-84 investors in ASHRAE Research is in three sections. The first section is a listing by the amount of the contribution, ranging from $250 to more than $10,000. All contributions of $100 or more are listed by region in the second section. The third section recognizes the special contributions made by individuals, chapters and organizations as ASHRAE Research memorials to deceased individuals.

There were many, many additional contributors of amounts less than $100 who are not listed. The number of contributors of $100 and more demonstrates the monumental task it would be to name every contributor.

We have been diligent in our efforts to list contributions correctly. In an Honor Roll of this size, however, errors will occur.

We apologize for any errors.

Investors of $10,000 and more

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Region I

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HONOR ROLL INVESTORS IN ASHRAE RESEARCH 1983-84

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Grumman Aerospace Corp.
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The Hartford Steam Boiler Inspection & Insurance Co.
Richard C. Hill
Hiross Incorporated
Martin Hirschorn
E. W. Hoffmann, Inc.
R. L. Horridge & Associates Inc.
Hurley & David Inc.
IBM Corporation
International Exposition Co., Inc.
William Jacobs & Sons
Sam C. Jaffe Mechanical Sales
Jaffie Mechanical Inc.
Jaros Baum & Bolles
Kagan and Clinton Inc.
Kalisch-Jarcho Inc.
Kallen & Lemelson Princeton Junction
Kallen & Lemelson/New York City
R. L. Kistler Inc./Syracuse
R. L. Kistler Inc./Rochester
KTC Sales Corporation
Levings Trane Sales Agency
James L. Lewis Incorporated
Howard Z. Lieb & Company, Inc.
Lizardos Engineering Associates
Long Island Chapter/ASHRAE
Long Island Lighting Co.
Lozier Incorporated
George B. H. Macomber Co.
Morris L. Markel
R. D. Marshall & Co., Inc.
Mason Berger East Inc.
Master Cooling Corporation
R. G. Maupai Company, Inc.
Frank A. McBride Co./Hawthorne
Donald McGeddy, P.E., P.C.
Mechanical Contractors Association of Dutchess & Duster Counties
Mechanical Contractors Assn. of Rochester/Rochester
Mechanical Insulators of New England
Mechanical Systems Engineers
Meier Supply Company, Inc.
James H. Merritt & Company
Millander-Wilke Inc.
Monsen Engineering Co.
Montgomery Engineering Co.
Bruno P. Morabito
Manfred Moses
John Edward Moyer
Murphy Encon Incorporated
NYSE&G Corporation
Nassau County Association of Plumbing, Heating & Cooling Contractors
National Plumbing & Heating Supply Corp.
New England Air Systems Inc.
New York Chapter/ASHRAE
Niagara Frontier Chapter/ASHRAE
Niagara Mohawk Power Corp.
Nohle Refrigeration Supplies
Norris & Seibert Inc.
Nortec Industries Inc.
North Jersey Chapter/ASHRAE
Northeast Mechanical Sales Corp.
Northeastern Incorporated
Northeastern New York Chapter/ASHRAE
Northeastern Sheet Metal Inc.
Northern Engineering Associates
Northway Engineering Inc.
Armand P. Nuzzi
O'Brien & Gere Engineers
D. Ober Associates Inc.
David J. Ober
Thomas J. Odea
William B. Osgood Associates Inc.
Dueliette Plumbing & Heating Corporation
PRC Harris
R. F. Peck Company, Inc.
Personius Wadsworth and Molter
Peterson Associates Inc.
Plumbers & Pipefitters Union Local 112
Postler & Jackle Corp.
The Prudential Insurance Company of America
Ted Reed Thermal Inc.
Refrigeration Service Engineers Society, Central New York/Syracuse
Rist-Frost Associates P.C.
Robson & Woese Inc. Consulting Engineers/Syracuse
Robson & Woese Inc. Consulting Engineers/Penfield
Rochester Chapter/ASHRAE
Rochester Gas & Electric
Rodgers & Associates Inc., Manufacturers Agent
Rose Beaton & Rose FDN
Leo J. Roth Corporation
Rudin Management Co., Inc.
SMACNA/Rochester
H. Sand & Company, Inc.
Scallop Thermal Management Inc.
Edward A. Sears & Associates
Segner & Dalton, Consulting Engineers
Sheet Metal Contractors Association of Union, Morris, Somerset & Sussex
Simpson Metal Industries
Slant/Fin Corporation
E. G. Snyder Company, Sheetmetal Division
Southern Tier Sheet Metal Contractors Association
Gaylon N. Spinney, Jr.
J. W. Stevens Company
Stillwell-Hansen Inc.
R. L. Stone Co., Inc. Rochester
TSBA Controls Inc.
Taco Incorporated
Tempco Incorporated/Warwick
Temperature Controls of Vermont
Tesco Distributors Inc.
Thermal Environment Sales Inc.
Thermco Incorporated
Tishman Realty & Construction Co.
Tougher Industries Inc.
The Trane Company North Jersey/Livingston
The Trane Company
Traulsen & Company, Inc.
Trimech Corporation
Turek Associates
Turner & Harrison
Turner Construction Co.
Twin City Supply Company
Twin Tiers Chapter/ASHRAE
Union Air Conditioning Inc.
Vanguard Industries Inc.
Vermont Gas Systems Inc.
Vermont Heating and Ventilating Company
Vico Vibration & Noise Control Inc.
Ralph F. Visco Consulting Engineers
Warkol Mechanical Corp.
Albert Weiss Air Conditioning Products Inc.
Philip H. Werner Inc.
Philip H. Werner
Western Mass. Chapter/ASHRAE
D. R. Whipple Company, Inc.
The Wing Company Div. of Wing Industries
L. Winik & Associates Inc.
A. D. Winston Corporation
Wolff & Munier Inc.
F. N. Zaino Associates

Region II

Investments of
$100 and more

ACME Engineering Products
AJAX Air Conditioning Co., Ltd.
All Energy Engineering Ltd.
Arnon Development Corp., Ltd.
A. G. Baird Ltd.
Beaver Engineering Ltd.
Peter Bevan Ltd.
BFH/Shawinigan/Ottawa
James Black & Associates
Black & McDonald Ltd.
Bole Incorporated
Boone Plumbing Supply
Howard Boyle Air Conditioning Ltd.
Canadian Blower Canada Pumps Ltd.
Canadian Blower Hamilton Canadian Pumps Ltd. Hamilton Branch
Carmichael Engineering Ltd.
Carrier Canada Limited Bramalea, Ontario
Carrier Distributors Ltd./Montreal
Carrier Est/Eastern
Cauchon Girard & Associates Inc.
Central Insulation Ltd.
Chauffage Moderne (1973) Ltd.
Chebucto Engineering Ltd.
Chorley & Bissett Ltd.
Chromalox Canada Inc. Pointe-Claire
Chromalox Canada Inc./Rexdale
Clemann Large Patterson Associates
Climatisation Master Ltee.
Clomac Holdings Limited
Comstock International Ottawa, Ontario
Paul R. Conrad HVAC, Ltd.
Consulgaz General
Consumers Gas Company
Controls & Equipment Ltd.
Crane Supply/Moncton
Crane Supply/Ottawa
DHM Energy Consultants Ltd.
Davie Environmental Equipment
De Leuw Cather Canada Ltd.
Delhi Industries Ltd.
Ted Digel Sales Ltd. Trane Service Agency
Dilfo Mechanical Ltd.
M. M. Dillon Consulting Engineers & Planners
Du Pont of Canada Ltd.
James R. Duncan
The ECE Group
Eastcan Consultants Ltd.
Federal Air Conditioning and Refrigeration
W. R. Ferguson Electric Ltd.
H. G. Francis and Sons
Frigo Engineering
Frontier Commercial Refrigeration Limited/Ottawa
R. L. Fulton Equipment Ltd.
GEC Canada Limited
Germain Mechanical & Electrical Limited
Gilbert Bourassa Gagne Morin & Associates Ltee.
Gillies-Guy
Goodkey Weedmark & Associates Ltd.
Greenall Heating & Air Conditioning Ltd.
Leo Groulx Plumbing & Heating Ltd.
Group Eight Engineering Ltd.
Groupe Conseil Saguenay
Roland Guillemette Inc.
HVAC Incorporated Chomedey Laval
HVAC Incorporated/Laval
G. Hayball & Associates Ltd.
Charles B. Hobbs
Honeywell Limited/Scarborough
Honeywell Limited/Willodale
Jo-Ad Industries Limited
Jo-Ad Industries Ltd/Pointe Claire
Johnson Controls Ltd./Ottawa
Johnson Controls Ltd./Bedford
Johnson Controls Ltd. Toronto, Ontario
Johnson Controls Ltee./Quebec
Keeprite Products Inc./Brantford
Jacob Klassen
Francois L'Anglais
Lalonde Girouard Letendre & Associates Ltee.
J. Landry Mechanical Sales Ltd.
Laval Spirotube Inc.
Lavallin Incorporated
Lejoie Somec Incorporated
Les Consultants Boulay Leclerc Et Associates
Lisi Aero-Guide Inc.
Longhill Energy Products (Eastern Limited)
J. Lunde & Associates Ltd.
M & M Engineering Ltd.
MCC Powers/Ottawa
Mastercraft Development Corp.
Mastron Mechanical Contractors Ltd.
McCarthy & Robinson Inc.
McDonald & Willson Refrigeration Ltd.
McKee Lockhard and Associates Ltd.
Mechanical Contractors Assn. of London
Mechanical Contractors Assn./Niagara
Merit Mechanical Ltd. Lower Saskville
Minto Construction Ltd.
Modern Mechanical Co. Ltd.
Montclair Incorporated
Morris & Richard
Nailor-Hart Industries Inc.
Nortec Air Conditioning Industries Ltd.

F.C. O'Neil Scriven and Associates Ltd.
Oakes Mechanical Contracting Ltd.
Oboe Engineering Ltd.
Ontario Hydro
Ottawa Plumbing & Heating (1970) Ltd.
Pageau Morel & Associates/ Montreal
Papeterie Reed Ltee.
Peninsula P & H Supply Co. Ltd.
Poly-Mecanique (1979) Inc.
Preston Phipps Inc./Montreal
T. Pringle & Son Ltd.
Ravcor Refrigeration Inc.
Rheem Canada Incorporated
J. L. Richards and Associates Ltd.
J. C. Robinson & Sons Ltd.
Ross & McNeilage Limited
SNC
Peter B. Sauer
Scan Air Balance Ltd.
John M. Schermerhorn Ltd.
Smith & Andersen Consulting Engineers/Ottawa
Smith & Andersen Consulting Engineers/Toronto
Steen Contractors Ltd./Toronto
Bruce Sutherland Associates Ltd.
Teledyne Laars Canada
Temprite Industries Ltd./London
Theberge & Belley Inc.
Thermolec Limited
Thermolec Ltee.
Malcolm S. Thompson
Toronto Chapter/ASHRAE
Trane Company of Canada Quebec
Trane Sales Agency Division of Sweeney Sales
Trisar Limited
Trizec Equities Ltd.
Trolec Incorporated
D. J. Troupe & Associates
Union Gas Limited/Hamilton
Union Gas Limited/London
Vander Western and Rutherford Ltd.
Ventilex Incorporated
Viessmann Manufacturing Co. Inc.
B. D. Wait Company Ltd.
Walmar Agencies Division of KFRB Agency
Watts & Henderson Ltd./Ottawa
Watts & Henderson Atlantic Ltd.
Westburne Industrial Enterprises Ltd.
Wiles-Legault and Associates Ltd.
P. M. Wright Ltd.
York Division Borg-Warner Rexdale
Z-Air Fabrication Inc.

Region III

Investments of
$100 and more

ARC Welder Sales & Rental Co., Inc.
AVM Mechanical Contracting Corp.
Bernie D. Abel, P.E.
Henry Adams Incorporated
Air Products & Chemicals
Air Systems Inc./Roanoke
Aircon Limited/Chesapeake
Airpac Systems
Frank Albert Inc. Mechanical & Electrical
Alberti-Faller Company
Allion Chemical Company
Allstate Sheet Metal Inc.
American Gas Association
Anonymous
Anthracite Chapter/ASHRAE
Appalachian Heating and Insulation Co.
ASHRAE Headquarters
ASHRAE School Instructors, Philadelphia Chapter
Atlantic Electric
Automatic Equipment Sales of Roanoke
Automatic Equipment Sales of Charleston
B & M Sheet Metal Shop Inc.
The Baase Company
Ballinger Architects, Engineering Planners
Baltimore Air Balance Co.
Baltimore Aircoil Co., Inc. Baltimore
Baltimore Chapter/ASHRAE
Baltimore Gas & Electric
M. Nelson Barnes & Sons Inc. Mechanical Contractors
Barton Associates Inc.
Bay Mechanical Inc.
Edwin L. Bell, Jr.
R. D. Bitzer Company, Inc.
Bohannon Staley and Associates
Boland Trane Service
Borg-Warner Air Conditioning Inc.
Robert C. Bost Associates Inc.
P. C. Bowman & Associates
Brandt Ricci Riley inc.
Donald L. Brandt
Martin J. Braun Inc.
Broudy Precision
Burdette Koehler Murphy and Associates
C & H Mechanical Corp.
CII Engineered Systems Inc.
CLR Incorporated
T. A. Carter, Jr., Architect
Catalytic Incorporated
Central Pennsylvania Chapter/ASHRAE
A. T. Chadwick Co., Inc., Al Chadwick
Chasney & Company Inc.
J. T. Claus Incorporated
F. C. Clifford Incorporated
Commonwealth Kinetics Co., Inc.
Lyon Conklin & Co., Inc.
Kenneth W. Cooper
Coward-Eastman Inc.
L. H. Cranston & Sons Inc.
DMR Associates Inc.
Curtis E. Davis, Jr.
Day & Zimmerman Inc.
Delaware Chapter/ASHRAE
Delaware Mechanical Contractors Assn.
Delmarva Power & Light Co.
The Dexter Company
William J. Donovan Co.
Dougherty Company Inc.
E. I. dupont de Nemours and Co., Inc.
Leland D. Eisenhower Ltd.
Electrical Mechanical Specialists Co.
E. Charles Emerson
Emtech Incorporated
Energy Products Company
Energy Systems Engineering Inc. Kensington
John Engalitcheff, Jr.
Engineered Sales and Service Inc.
Environcon Association Inc.
Environmental Air Inc.
Evapco Incorporated
Ewing Cole Cherry Parsky
Fireguard Sprinkler Co., Inc.
Fluidics Incorporated
Kerry D. Freeman
GSGSB
Galax Plumbing & Heating
The Garing Corporation Honesdale
Gerngross Corporation
Herbert T. Gilkey
Gipe Associates Inc.
Girard Engineering Ltd.
Herman Goldner Company
Morton Goren
T. A. Gorman Incorporated
I. D. Griffith Inc.
H & H Associates
HDR
J. A. Hagan Jr. & Company Mechanical Equipment
Harris Heating and Plumbing Co., Inc.
Fred Hayes Mechanical Contractors Inc.
Hayes Seay Mattern & Mattern
G. J. Hopkins Incorporated
Hummer Equipment Co., Inc.
Industrial Air Conditioning Co. Falls Church
Ingleside Contractors Inc.
Robert E. Innes
J. K. Mechanical Products Inc.
Jenkins Associates Inc./Tuxedo
Richard M. John
Jerre D. Kates Inc.
Lou D. Keller Incorporated
Kidde Consultants Inc.
John J. Kirlin Inc.
Kling Lindquist Inc.
The Lamb Engineering Co.
Lee-Thorp Incorporated
Lehigh Valley Chapter/ASHRAE
Stanley L. Leitsch
Charles Logan Estate, C/O Philadelphia Chapter/ASHRAE
Nash M. Love & Associates Inc.
Robert S. Lovelace Company, Inc.
David S. Lowe Company, Inc.
Lowe Mechanical Inc.
H. T. Lyons Incorporated
MMM Design Group
Machinery & Equipment Sales Inc.
Mack Trucks Incorporated
Marley Cooling Tower Co. Philadelphia
E. M. Martin Incorporated
Martin/Rogers/Associates
Mayes Engineering Inc.
McArdle & Walsh Inc.
McCormick Properties Inc.
McNeil Consumer Products
James R. McQuaide Inc.
Mechanical Construction Associates Inc.
Mechanical Contractors Assn. for District of Columbia
Mechanical Contractors Assn. East Pennsylvania Inc.
Mechanical Contractors Assn. of Maryland/Towson
Ernest D. Menold Inc.
Metz Mechanical Contractors
Meucci Engineering Inc.
Monumental Supply Co., Inc.
G. F. Morin Company
Mueller Associates Inc.
J. Donald Munson
National Capital Chapter/ASHRAE
Jess Newbern III
Jess Newbern Incorporated
Patterson-Kelly Company
Peabody & Wind Engineering Corp.
Pierce-Phelps Inc.
Penn Ventilator Co., Inc. Philadelphia
Pennell & Wiltberger Inc.
Pennsylvania Gas and Water Co.
Pennsylvania Power & Light Co./Allentown
Pennwalt Corporation, Isotron Dept.
Lawrence Perry & Associates Inc.
William B. Peters
Petro & Jennings Inc.
Philadelphia Chapter/ASHRAE
Philadelphia Electric Co.
Clinton W. Phillips, P.E. Engineering Consultant
R. A. Picard Incorporated
Pipe Incorporated
Pittman Mechanical Contractors
Pittsburgh Chapter/ASHRAE
Pittsburgh Plumbing & Heating Supply Corp.
The Poole & Kent Company
James Posey Associates Inc.
Power Engineering Corp.
Prefco Products Inc.
Progressive Products Corp.
Reid Associates Inc. Virginia Beach
John H. Renninger Inc.
Richmond Chapter/ASHRAE
Riddleberger Brothers Inc.
Roache Mercer & Falson Inc.
Roanoke Chapter/ASHRAE
Roanoke Gas Company
John Robert Associates Inc.
Roofing & Sheet Metal Contractors Association of Philadelphia
Raymond E. Ruf
SMACNA/Wilkes Barre Industry Advancement Fund
Sanders & Thomas Inc./Pottstown
Richard J. Santee
Robert C. Sars & Associates
John F. Scanlan Inc.
Schneider Incorporated
Schumacher & Seiler Inc.
Service Unlimited Inc.
Shafer Troxell & Howe Inc.
Shefferman & Bigelson Co.
William D. Shellady Inc.
Robert J. Sigel Inc.
Smithkline Beckman Corp.
E. J. Snyder Incorporated
Southern Air Incorporated
Sowers Rodes Whitescarver
Walter F. Spiegel Inc. Consulting Engineers
John B. Staley
Strickler Associates P.C.
Tate Engineering Inc.
Taylor Lipscomb & Appel Inc.
Taze & Hewitt Inc.
M. J. Thompson III Consulting Engineers
The Trane Company, Allentown Sales Office
Trane Penn Service Co.
J. L. Turner Company
UGI Corporation
United Engineers
United Products Distributors Inc.
Utility Engineers Inc.
Valley Air Conditioning Corp.
Vansant & Gusler Inc.
Dimitri J. Ververelli Inc.
Virginia Electric and Power Co.
Virginia Trane Service Agency Inc.
Volair Contractors Inc.
David Volkert & Assoc. Inc.
Waldron Incorporated

HONOR ROLL INVESTORS IN ASHRAE RESEARCH 1983-84

Ward-Boland Equipment Co., Inc.
Warner Mechanical Corp
Washington Gas Light Co.
Weddle Plumbing & Heating Co.
Weisman Incorporated
The Whalen Company
William H. White, Jr. Inc.
William F. Wilke Inc.
Harry M. Will, Jr. Inc.
Frank E. Williams, Jr.
  Consulting Engineer
Williard Incorporated
Francis E. Woods
Wyeth Laboratories Inc.
N. H. Yates & Co., Inc.
York Division Borg-Warner
  Alexandria
York Division Borg-Warner
  Baltimore
Carl J. Zeller Inc.
William T. Zielinski, P.E.

Region IV

Investments of
$100 and more

Adams Shadrick Davis
Air Conditioning Corp.
  Greensboro
Aircond Corporation/East Point
Britt Alderman and Associates
Britt Alderman, Jr.
Applebee-Church
Richard E. Armentrout
Armour & Cape Incorporated
Associated Heating & Air
  Conditioning Supply Inc.
Atlanta Chapter/ASHRAE
Atlanta Gas Light Co.
B & W Mechanical
  Contractors Inc.
The Bahnson Company
F. A. Bailey & Sons Inc.
Tom Barrow Company/Atlanta
Percy D. Bartholomew, Jr.
Batchelor & Kimball Inc.
Bell South Services
Benner & Fields Inc.
Berkley Heating Company
Biemann & Rowell Co.
J. G. Blackmon & Associates Inc.
Bolton Corporation
Bootle Equipment Sales &
  Service Inc.
Brady Trane Service Inc.
William D. Bruce
John Q. Bullard Associates Inc.
Burlington Industries Inc.
Byroc Insulation Supply Inc.
Captive-Aire Systems Inc.
Carolina Power & Light Co.
Chiller Services Inc.
Clary and Associates
Clontz-Garrison Mechanical
  Contractor Inc.
Coastal Supply Company, Inc.
Walter Cohen & Associates
Cone Mills Corporation
William L. Cooper
Cowan Supply Company
Crockford-Hall Associates Inc.
Cullum Mechanical
  Construction Inc.
Cummings & McCrady
Roger E. Cundiff
Cecil B. Day Companies, Inc.
J. R. Deans Company
Design Associates
Duke Power Company
Dulohery Weeks & Gagliano Inc.
  Consulting Engineers
Sarah Duwell
EMDS Incorporated
Environmental Products Sales
  Incorporated/Charlotte
Environmental Air Systems
Edwin W. Evans
Richard E. Faulkner Air Sales Inc.
Felkel & Hastings, Consulting
  Mechanical Engineers
Fenner & Proffitt Inc.
Ferguson/Sullivan Inc./Raleigh
Ferguson/Sullivan Inc./Charlotte
Freeman-White Associates Inc.
Gatley & Associates Inc.
Graves Refrigeration Inc./Atlanta
Greenville Chapter/ASHRAE
Robert V. Griffith
Guilford Mills Inc.
HVAC Systems Inc.
Ronnie D. Hackett
Hardwick-Morrison Company
Heat Transfer Sales Inc.
  Greensboro
Heat Transfer Sales Inc./Clover
Heery & Heery
Hickory Sheet Metal Co., Inc.
Hicks & Ingle Corp./Charlotte
C. R. Hipp Incorporated
Hockaday Heating and Air
  Conditioning Co., Inc./Raleigh
Hoffman & Hoffman Inc.
  Greensboro
Louis B. Hoffman
Orlando W. Hogan, Jr.
George Holden and
  Associates Inc.
George Holden, Jr.
Hub-Carolina Incorporated
Hudson Associates Inc.
Hydro-Air Associates Inc.
Industrial Air Inc./Greensboro
Industrial Maintenance Corp.
  Charlotte
Ingersoll-Rand Co./Charlotte
Ingold Company Inc.
Ivey's Inc.
R. C. Jacobs Plumbing, Heating
  and Air Conditioning Inc.
Ruffie A. Jones, Jr.
Kirby Heating & Air
R. F. Knox Co., Incorporated
Kru-Kel Company Inc.
Lincoln Associates
Lockwood Greene Engineers Inc.
  Atlanta
Low Country Contractors Inc.
Mallory & Evans Inc.
Robert E. Mason & Co., Inc.
McKenney's Incorporated
McKnight-Smith Engineers Inc.
Dan McNeil Company
Mec-Tric Control Company
Mechanical Contractors Assn.
  South Carolina
Mechanical Engineers Inc.
  Charlotte
Mechanical Industries Council
James A. Merritt and Sons Inc.
Metro Refrigeration Supply Inc.
Meyer & Company
Ronald W. Miller
Mingledorff's Incorporated
Monroe Metal Mfg.
Bruno P. Morabito
Morrison & Associates P.A.
Murray Supply Company
Newcomb and Boyd
Noland Company/Charleston
North Carolina Natural Gas Co.
Nottingham Brook &
  Pennington P.C.
O'Brien/Atkins Associates
Odell Associates Inc.
Alex C. Ormond
Parsons Brinckerhoff
  Quade & Douglas Inc.
George N. Payne, Jr.
Peachtree Trane
  Air Conditioning Co.
J. N. Pease Associates
Piedmont Natural Gas Co., Inc.
Piedmont Trane
  Air Conditioning Co.
Player and Company
James M. Pleasants Co., Inc.
Joe Powell & Associates Inc.
Professional Engineers &
  Designers Incorporated
Public Service Company
  of North Carolina/Gastonia
Purafil Incorporated
Rast & Associates Inc.
David Rickelton
Rivers Sheet Metal Inc.
Rosser White Hobbs Davidson
  McClellan Kelly Inc./Atlanta
Sanders Brothers Inc.
Savannah Bank & Trust Co.
Savannah Chapter/ASHRAE
Savannah Electric & Power Co.
Seacoast Mechanical Inc.
Seasons 4 Incorporated
Servidyne Incorporated
David N. Shultz Associates
South Carolina Chapter/ASHRAE
South Carolina Electric & Gas Co.
Southern Energy Company
Spauschus Associates
Standard Insulation Co./Raleigh
Stanford and Toomey
Stevens & Wilkinson
Stipp & Powell Inc./Greensboro
Streater Sales Inc.
Stromquist & Company, Inc.
Suggs Sales & Service Inc.
W. H. Sullivan Company, Inc.
Major Summerford
Harold Swygert and Associates
Tab Services Incorporated
Taylor and Associates Inc.
John H. Teague
Thermal Engineering Co.
Thermo-Industry of Charlotte Inc.
Cunnighan P. Thomas, Jr.
W. L. Thompson Consulting
  Engineers, Inc
The Trane Company
  Atlanta Sales & Service
The Trane Company
  Layne Trane/Service
Tri-Meck Mechanical Inc.
Triangle Chapter/ASHRAE
John L. Underwood Co., Inc.
Jack Walters Incorporated
Irving Weinberg
A. O. White
W. A. Wood & Associates Inc.
Stephen S. Woodrow
Woodward & Company, Inc.

Region V

Investments of
$100 and more

Aerodynamics Inspecting Co.
Air Engineers and Conditioning
  Company/Kalamazoo
Air Enterprises Inc./Akron
Akron Area Plumbers and
  Pipefitters Industry Fund
Akron Chapter/ASHRAE
Alliance Air Conditioning
Allied Supply Co., Inc.
W. T. Andrew Company
Anonymous
Arkla Industries Inc.
Balfrey & Johnston Inc.
Bosch Mechanical
  Contractors Inc.
J. Brodie & Son Inc.
Everett I. Brown Company
Bryant-Habegger Company
William R. Budde
Bumler Heating & Specialties Inc.
Byers Engineering Company
Cincinnati Chapter/ASHRAE
Columbia Gas of Ohio
Columbus Automatic Sprayer Co.
Columbus Chapter/ASHRAE
The J. H. Comins Company
D. J. Conley Associates Inc.
Construction Assn. of Michigan
Controlled Air Inc.
The Coon-Devisser Company
Copeland Corporation
Dee Cramer Incorporated
Criner & Wedeven Inc.
Robert W. Crosby
Dalton-Dalton-Newport Inc.
Dayton Chapter/ASHRAE
Deleasco Incorporated
R. L. Deppmann Co./Southfield
R. L. Deppmann Co./Saginaw
R. L. Deppmann Co.
  Grand Rapids
Detroit Edison Company
Diclemente-Siegel
  Engineering Inc.
The Thos. J. Dyer Company
The East Ohio Gas Company
Eastern Michigan
  Chapter/ASHRAE
Andy J. Egan Company, Inc.
Ellis-Naeyaert-Genheimer
  Associates
E. W. Ensroth Company
Environair Incorporated
Finkbeiner Pettis & Strout Ltd.
Firestone Tire & Rubber Co.
Fisher & Wright Inc.
Fontanesi & Kann Company
Ford Motor Company, Plant
  Engineering Office/Detroit
Foremost Manufacturing Co.
Frisch's Big Boy
Gardiner Service Company
  The Trane Company
J. W. Geopfert & Co., Inc.
Giffels Associates Inc./Southfield
Heapy Engineering Consulting
  Engineers/Dayton
Heating & Air Conditioning Assn.
Helmig-Lienesch-Doench
  and Associates
Honeywell Inc.
  Commercial Div./Farmington
Hoyem-Basso Associates
Hubert Trane Service Agency
Hughes-Bechtol Inc.
Huron Valley Sales Corp.
Industrial Energy
  Conservation Inc.
Johnson Sales & Engineering Co.
KZF Incorporated, Architects,
  Engineers, Planners
Albert K. Kahn Associates Inc.
Leggette-Michaels
Libbey-Owens-Ford Company
Limbach Company/Pontiac
Lorenz & Williams Inc.
Ralph E. Maly Incorporated
Marathon Oil Company
Mechanical Contractors
  Association of West Ohio
Mechanical Contractors Industry
  Promotion Fund/Columbus
Mechanical Design
  Associates Inc.
Mechanical Heat & Cold Inc.
Michigan Air Products/Royal Oak
Dan E. Morgenroth, P.E.
W. Bruce Motz

Mussun Sales Inc./Akron
Thomas C. Nash Inc.
Ohio Edison Company
The H. J. Osterfeld Company
Outwater Sales Inc.
Owens-Corning Fiberglas/Toledo
J. Pappas Associates Inc.
Patterson-Trane Service Agency
Pedco E & A Services Inc.
Philips Industries Inc.
J. M. Pier Company
Pipe Systems Inc.
Po.apa Mancini & Associates Inc.
Prestcold (North America)
Progressive Engineering Consultants of Grand Rapids Inc.
Reckinger Heating & Cooling Co.
Refrigeration Sales Corp.
Refrigeration Service Engineers Society/Toledo
Rieck Mechanical Services Inc.
Rogind/Parker/Curtis Inc. Grand Rapids
SMACNA/Flint Area
The Seakay Company, Inc.
A. J. Segal & Sons Contractors Incorporated
Skuttle Manufacturing Co.
Smith Hinchman & Grylls Associates Incorporated
Julian Speer Company
Stan & Associates Inc.
The Stanley-Carter Co.
Ralph C. Steele
Stock & Associates Inc.
Sullivan Sales Company
TMP Associates Inc.
Tecumseh Products Co.
Temperature Engineering Corp.
John R. Titus
Toledo Chapter/ASHRAE
Toledo Heating and Air Conditioning Contractors Association
The Trane Company Flint/Lansing/Saginaw
James A. Tudas
Ventcon Incorporated
WHB Associates Inc.
Western Michigan Chapter/ASHRAE
Whirlpool Corporation
The Williamson Company
Robert A. Wilson & Co.
Ruth E. Wocholski

Region VI

Investments of $100 and more

Abbott Laboratories
Adel Furnace Wholesalers Inc.
Advance Mechanical Systems Inc.
Affiliated Engineers Inc.
Affiliated Steam Equipment Co.
Air Comfort Corp./Broadview
Air Filter & Equipment Corp./Chicago
Air Products Equipment Co. Elk Grove Village
Airtex Corporation/Chicago
Albers Sheetmetal & Vent Inc.
Allan Heating & Air Conditioning Inc.
A. J. Allen Mechanical Contractors Inc.
Andersen Corporation
James H. Anderson Inc.
Anderson-Snow Corporation
J. Anderson's Super Bowl Party
Auer Steel & Heating Supply Co.
Bank Building Corp. Foundation
Barber-Colman Co./Rockford
Joseph L. Baruzzini
R. A. Behrmann and Associates Inc.
Beling Consultants Incorporated
Brian Berg & Associates Ltd.
Blackmore & Glunt Inc.
R. M. Boggs Company, Inc.
Booker Associates Inc.
Bornquist Incorporated
Thomas W. Brady
Brasch Manufacturing Co.
Bridges-Gallagher Inc.
Brooks Bory & Skiles
Edward J. Brown
Building Service Industry Sales Company, Inc.
C & R Heating & Service Co., Inc.
R. W. Cardella Incorporated
C. O. Carlson Air Conditioning Co.
Carney Fleming & Company, Inc.
Central Illinois Chapter/ASHRAE
William P. Chapman
Chase Supply Company
Chicago Chapter/ASHRAE
Chicago Conditionaire Co.
The W. Clasmann Corp.
Cleaver-Brooks
Climatemp Incorporated
Coad Rascovar Associates
Colton/Lester Corporation
Control Consultants and Supply Co.
Crawford & Witte Inc.
Deluxe Check Printers Inc.
Philip A. Dugan
Emerson Electric Company Alco Controls Division
Environmental System Design Chicago
Ericksen Ellison & Associates Inc.
Fidelity Bank & Trust Co.
G. A. Fisher & Co., Inc.
Bert Fredericksen Inc.
Friemel-Love Comany
Gartner Refrigeration & Manufacturing Inc.
The Gorgen Company
Greenheck Fan Corporation
Grumman/Butkus Associates
HSR Associates
Curtis C. Hammer
Hart-Hammer Division of S/V
Heating Piping Cooling Council
Hellmuth Obata and Kassabaum Inc.
Henry Valve Company
Hoffman/Trane
Honeywell Incorporated
Hooper Foundation
Horwitz Incorporated
Hubbell Corporation
Hydro-Flo Products Inc.
ITT Bell & Gossett Fluid Handling Division
Illinois Chapter/ASHRAE
Illinois Supply Company
Illowa Sheet Metal Contractors Association
The Louis Imbert Corp.
Industrial Engineering & Equipment Co.
Iowa Chapter/ASHRAE
Iowa Gas Company
Iowa Illinois Gas & Electric Co.
Iowa Power & Light Co.
The Robert Irsay Company
Johnson Controls Foundation
KJWW Engineering
Lawrence R. Kienzler
The King Company
Krack Corporation
Fred W. Kramer and Associates Inc./Elk Grove Village
L & S Insulation Co., Inc.
Laclede Gas Company
Robert J. Ladner Environmental Systems Design Inc.
Gustave A. Larson Company
Jerry P. Lebow
Lennox Industries/Milwaukee
The Lockformer Company
MCC Powers Controls/Skokie
Maddock Mechanical Industries
Manci & Haning Inc.
Robert A. Martini
Oscar Mayer Food Corp.
McCotter & Hansen Inc.
Robert O. McDonald
McQuay Perfex Inc./Minneapolis
Mechanical Contractors Assn. Central Wisconsin
Mechanical Contractors Assn. St. Louis
Mechanical Products & Systems Inc./St. Louis
Meredith Corporation & Merdith/Burda
Michaud Cooley Hallberg Erickson & Associates Inc.
Milwaukee Stove and Furnace Supply
Milwaukee Valve Co., Inc.
Minnesota Chapter/ASHRAE
Minnesota Energy Conference
Modine Manufacturing Company
Monsanto Fund
F. E. Moran Incorporated
A. K. Morris & Associates Inc., Morris/Trane Serv. Agency
Bernard J. Mulcahy Co., Inc.
Murphy Company
N. E. Wisconsin Chapter/ASHRAE
H. S. Nachman & Associates Inc.
Northern Illinois Gas Co.
Northern States Power Co. Minneapolis
Northwest Bank/Des Moines
Northwestern Bell Telephone Co. Omaha
Opus Corporation
Theodore E. Pannkoke
Parker Hannifin Corp. Refrigeration Components Group/Broadview
C. Patz Company
Peoples Gas Light & Coke Co.
Peoples Natural Gas Co. Dubuque
Petersen Plumbing and Heating Co.
Plumbing & Mechanical Contractors Assn. of Milwaukee & S.E. Wisconsin
Poja Heating & Sheet Metal Company, Inc.
Stewart W. Primrose
Frank Pulley & Associates Inc.
Quint Company Inc.
Ralston Purina Co.
Research Products Corp.
Ross & Baruzzini Inc.
John D. Roth
SMACNA/St. Louis
SMARNA of Minnesota
The Schebler Company
Schwab-Vollhaber Inc.
Senco Services Corp.
Service Parts Company
Setter Leach & Lindstrom Inc.
H. C. Sharp Company
Sheet Metal and Air Conditioning Contractors Association
Sheet Metal Contractors of Iowa West Des Moines
Sheet Metal Contractors Assn.
Skidmore Owings & Merrill Chicago
Sporlan Valve Company/St. Louis
St. Louis Chapter/ASHRAE
Standard Machine and Mfg. Co.
Standard Refrigeration /Autorad Inc.
Stanley Consultants Inc.
C.T. Stone, Jr. Inc.
R.S. Stover Co./Marshalltown
Strang Partners Inc.
Sullair Corporation
Sverdrup & Parcel and Associates Inc./St. Louis
Swanson Company Inc.
Systems Management & Balancing Inc./Des Moines
E. J. Taff Sales Co., Inc.
Taylor Insulation Co.
Temperature Systems Inc.
Jack R. Tennill & Associates Inc.
Thermo King Corporation
Thermo Piping Inc.
Thermo-Dyne Incorporated
3M Company
Total Maintenance Inc.
The Trane Company/La Crosse
The Trane Company/Minneapolis
Trane Davenport
Universal Climate Control Inc.
Vilter Foundation Inc.
Vyron Corporation
H. F. Wallace Company/St. Paul
Wilkins Pipe & Supply Co.
Wisconsin Electric Power Co.
Wisconsin Gas Company
Wisconsin Telephone Co.
Wisconsin Insulation Contractors Assn.
Woodward Governor Company

Region VII

Investments of $100 and more

ARC Incorporated
Air Comfort Engineering Inc. Montgomery
Air Engineers Inc./Birmingham
Air Filter Testing Labs Inc.
Air Tech Inc./Birmingham
Aircon Sales Agency Inc. Nashville
Airguard Industries Inc.
Alabama Controls Inc.
Alabama Gas Corporation
Alabama Power Company
Allen & Hoshall Inc./Knoxville
Allen & Hoshall Inc./Memphis
Allen Equipment Company
Allied Air Products Inc.
Allied Mechanical Contractors Inc.
American Air Filter Co., Div. of Allis-Chalmers/Louisville
Andrews Distributing Co.
Archer Air Conditioning Service Co., Inc.
ASHRAE Headquarters
Associates Mechanical Contractors Inc.
Automatic Icemakers Inc.
Automation Consultants Inc.
G. H. Avery Company, Inc.
B & J Mechanical Contractors Inc.
Baker Brothers Inc./Montgomery
Batchelors Mechanical Contractors Inc.

HONOR ROLL INVESTORS IN ASHRAE RESEARCH 1983-84

Ned W. Belt, Jr.
Bendall & Company, Inc.
Betz-Converse-Murdoch Inc., Engineers
The Blount Foundation Inc.
Boiler Supply Co., Inc./Knoxville
Boiler Supply Co., Inc./Nashville
Brock-McVey Company
Buford Plumbing Company, Inc.
Ben A. Burnette Company, Inc.
C & M Sales Incorporated
Campbell & Associates Inc. Chattanooga
Carrier Corporation/New Orleans
W. Jack Castell
Charles N. Catledge Co., Inc.
Central Kentucky Chapter/ASHRAE
Chattanooga Pipe Trades Industry Fund
Don Chesson & Associates Consulting Engineers
Coast Corporation
Coastal Insulation Co. of Pensacola Inc.
Coastal Mechanical Inc. Pensacola
Coastal Supply Company, Inc.
Columbia Gas of Kentucky Inc.
Colvin & Son Heating Co.
Comfort Control Company
Commercial Service Co., Inc.
Conaway-Colmer Inc.
Conditioned Air Service Co., Inc.
Consolidated Air Conditioners Inc.
Consumers Supply Company, Inc.
Continental Filter Corp.
Contractors Heating and Cooling Inc.
T. E. Cook & Associates Inc.
Cook and Nichol Inc.
Cooling & Heating Supplies
Creative Workshop
E. H. Crump Companies, Inc.
DSA Incorporated
Davis Mechanical Contractors Inc.
Dent Air Conditioning Co.
Dowdy & Associates Inc.
East Tennessee Chapter/ASHRAE
H. Murray Echols Consulting Engineer
Energy Conservation Systems Inc./Nashville
Energy Management Consultants Inc.
Engert Plumbing & Heating Inc.
Engineered Mechanical Equipment Inc./Memphis
Engineered Refrigeration Systems Inc.
Equipment Sales Corp./Mobile
Harold E. Faller & Associates Inc.
Fex Air Systems Inc.
Cary B. Gamble and Associates Inc.
James Terry Gaudet
General Electric Company
General Pipe & Supply Co.
Gorham-Schaffler Inc.
Gulf Power Company
Everett P. Hailey
Heat Transfer Equipment Inc.
Hemmer & Yates Inc.
R. D. Herbert & Sons Co.
Hibernia Equipment Corp.
Holiday Inns Incorporated
R. Holterhoff Associates Inc.
Howard & Howard Plumbing and Heating Contractors Inc.
Hughes Mechanical Contractors Inc.
Humber/Almond/Blythe Inc.
Ivey's Incorporated/Kosciusko
J & P Supply Company
Phillip R. Jones & Associates Inc.
Stanley Jones, Mechanical Contractor
Jones-Trane Service Co.
Keith Air Conditioning Inc.
Ken-Aire Systems Inc.
Klocke-McLaughlin & Associates Inc.
Charles R. Knights
Knoxville Utilities Board
Koch Filter Corporation
Kwik-Kold Corporation, Inc.
LSE Engineering Inc.
S. M. Lawrence Company, Inc.
Le Blanc & Assaf & Associates Consulting Engineers
Lee Company
Leopold & Orr Inc.
Levy-Kramer & Associates Inc.
Lockwood Greene Engineers
Incorporated/Oak Ridge
MCC Powers Controls/Skokie
Magnolia Air Conditioning and Supply Company, Inc.
Mann Mechanical Services Inc.
Mason & Dulion Company
Master Insulation Inc.
McInturff Company, Inc.
John P. McLarty
McWilliams Associates P.C.
Mechanical & Industrial Sales Inc.
Mechanical Construction Company of New Orleans Inc.
Mechanical Construction Association Inc./New Orleans
Mechanical Sales Inc.
Mechanical Systems International Inc.
Memphis Chapter/ASHRAE
R. E. Meyers & Associates Inc.
Miller & Weaver Inc.
D. M. Mills & Associates Inc.
Mississippi Power & Light Co.
Mississippi Valley Gas Co.
Edwin W. Moats
Mobile Gas Service Corp.
Mobile Mechanical Contractors Association Inc.
Mobile Supply Co., Inc.
Montgomery Chapter/ASHRAE
Nashville Gas Company
National A & R Supply
New Orleans Chapter/ASHRAE
New Orleans Public Service
Donald E. Nichols
North Alabama Chapter/ASHRAE
Northwest Florida Chapter/ASHRAE
Office of Griffith C. Burr Inc.
One Stop Supply Inc.
Palmer & Lawrence Inc. Birmingham
Gene Payne Associates Inc.
Poche Associates Limited
Pope Trane Company
Power Equipment Co./Memphis
Process & Power Inc.
Promotion Trust Fund for Plumbing & Pipe Fitting Industry of Memphis
R. N. Pyle Mechanical Contractors Inc.
Quality Mechanical Contractors Inc./Birmingham
R & H Supply Company
Refrigeration Supply Co., Inc. Mobile
Remtech Incorporated
Rheem Manufacturing Co.
Jim Robbins & Associates Inc.
Rome Eddleman & Associates Inc./Nashville
Wayne O. Rose
Rowan & Associates Inc.
Rust International Corp.
Ryan Mechanical Contractors Inc.
Sansing Sales Inc./Pensacola
Brian A. Schneider
James Schulze
Sellers Engineering Company
Sharpe's Icemaker Distributors Inc.
Sherlock Smith & Adams Inc.
D. F. Shoffner Mechanical Contractors Inc.
Smith Air Cond. Engineers
Smith Seckman Reid Inc., Consulting Engineers
Smith Service Corporation
Haynes S. Smith, Sr.
Walter B. Smith
W. A. Soefker and Son Inc.
Solar Unlimited Inc.
Southern Balance Inc.
Standard Heating and Air Conditioning Company, Inc.
Steel City Wholesalers Inc.
James W. Storey, Consulting Mechanical Engineer
E. K. Strahan Incorporated
Sverdrup & Parcel and Associates/Nashville
Tech Test Incorporated of Louisiana
Thomas Engineering Inc.
I. C. Thomasson and Associates Inc.
Raymond C. Thornton
The Trane Company/Birmingham
George Tucker & Associates
United Air Products Corp. Chattanooga
United Inns of Tennessee
Vantage Companies
Harry D. Wade, Jr.
Henry C. Waechter
Ward Mechanical Equipment
Watts Engineering Sales Inc.
Jim Wells & Associates Inc.
West Miller Welch Engineers Inc.
West Tennessee Sheet Metal Industry Fund
Westbourne Supply/Memphis
Wilson Engineering
A. H. Witt Incorporated

Region VIII

Investments of $100 and more

AAA Insulation & Sales Co., Inc.
AAE Incorporated
ABC Sheet Metal Works
AES of Oklahoma Inc.
AME Incorporated/Oklahoma City
Mrs. George T. Abbott, Jr.
Air Conditioning Contractors of America
Air Distribution Products Houston
Air Energy Recovery Co., Inc.
Aire Systems Mfg. Corp.
Airtop Heating and Air Conditioning Inc.
R.B. Akins Company
Allen Consulting Inc.
Allied Supply Inc.
Almar-York Company, Inc.
Alpha Mechanical Contractors Inc.
Ameco Incorporated
American Air Cond. Corp.
The Orin Anderson Co.
John L. Anderson
H.G. Angle Company, Inc.
Ark-Mo Services Corp.
Arkansas Mechanical Contractors
Arkansas Power & Light Co.
Arkla Gas Company/Little Rock
Arkla Gas Company/Shreveport
Armstrong Mechanical Co., Inc.
Ashcraft Company, Inc.
Association of Roofing, Sheet Metal & Air Cond. Contractors
James Austin Company
Austin Plumbing and Pipe Fitting Industry Fund
Austin Sheet Metal Industry Fund
Rex M. Ball
Barber-Colman Co./Little Rock
Bartos Incorporated
Beals Mech. Contractors Inc.
Beco Service Incorporated
Benco Incorporated
The Benham Group Inc.
Berg Mechanical Inc.
Berger Engineering Co.
Bernhard Associates
Binning-Trane Company
Blanke Mechanical Services
A.H. "Pappy" Blanke
James R. Blanke
Blass Chilcote Carter Lanford & Wilcox
Bloomquist & Associates
Blum Consulting Engineers Inc.
T.J. Boismier Company, Inc.
Arthur Bonifazi Company
Boone & Boone Sales Co., Inc.
Boune & Boone Sales Co.
Bovay Engineers Inc./Houston
Bradford Industrial Supply Corp.
Bradley Plumbing Inc.
Braeburn-De Witt Air Cond. Co.
Jack B. Buckley
Bullard-Hill-Roberson Co.
Billy Burley
Ray S. Burns & Associates
Burr Engineering Inc.
Burr Engineers Inc.
C & C Electric Construction Co., Inc.
CBS Mechanical Inc.
CHE Incorporated
The CV Company, Inc.
Charles D. Callahan
Cardinal Machinery Inc.
Bob Carow Company
R.M. Carpenter Co., Inc.
Carrier Bock Company/Ft. Worth
Carrier Bock Company/Irving
Carrier Bock Co./Shreveport
Carter and Burgess Inc.
Jack T. Carter Company, Inc.
Walter Cash and Partners Inc.
Central Oklahoma Chapter/ASHRAE
Century Mech. Contractors Inc.
Ceramic Cooling Tower Co.
Chenault & Associates Inc.
Cherokee Pump & Equipment
Cities Service Oil & Gas Corp.
Clark Mechanical Contractor Inc.
Climate Engineering Co./Austin
Joe H. Cloud & Son Plumbing
Cohn-Daniel Corporation
William J. Collins, Jr.
Collins-Soter Engineering Inc.
Comfort Engineering Co.
Comfort Incorporated
Computer Environments Inc.
Oliver A. Conrads
Cook & Holle Incorporated Consulting Engineers
C.C. Cooke Company
Cooper Supply Company
Crane Supply Company/Tulsa

Carolyn R. Crawford
The Cromwell Firm
Hugh M. Cunningham
Curry Incorporated
Harry E. Curry
Custom Sheet Metal Inc.
Cybernetic Systems Mgmt. Corp.
Dallas Chapter/ASHRAE
Dallas Power & Light
Michael J. Davidson
James B. De Moss
Howard E. Decker
The DeMoss Company, Inc.
Determan-Scheirman Inc.
Domestic Manufacturing Corp.
Dyna Ten Corporation
Dynasonics Incorporated
E & W Plumbing Co., Inc.
ESCO Supply Company
  Div. of Valero Energy Corp.
Ed's Supply Co./Little Rock
Edwards Sheet Metal Works Inc.
Eggelhoff Inc./Little Rock
Richard R. Ellis
The Emde Co., Inc./Houston
The Emde Company/Dallas
Enercon/Tulsa
Engineered Air Balance Co., Inc.
Engineered Machinery, York Div.
  Borg-Warner Corp./Ft. Worth
Entex Incorporated
Environmental Components Inc.
Erickson Industrial Products Inc.
Estes McClure & Assoc. Inc.
Fabricated Products Co.
Fanning Fanning & Agnew Inc.
Federal Corporation
Fitzgerald Contractors Inc.
Flower & Associates Inc.
Flynt & Kallenberger Inc.
Foley Mechanical Company
4M Company, Inc.
Fox & Hearn Incorporated
Frankfurt Short Bruzza Assoc.
H.W. Franklin Jr.
Freeman Equipment Company
Freer Mechanical Contractor Inc.
The Friday Corp./Fort Worth
Ft. Worth Chapter/ASHRAE
Ft. Worth Mechanical and
  Electrical Contractors
Ft. Worth Plumbing &
  Pipefitting Industry Fund
G & G Controls
John N. Gambrell
Garver & Garver Engineers Inc.
Gaynor & Sirmen Inc.
General Engineering Corp.
  Ft. Worth
General Mechanical
  Contractors Inc./Little Rock
Geren Associates
Gerling-Thomas-Ward Inc.
Gibbs Service Company, Inc.
Clarence Gilmore & Associates
Harley W. Goodman, Jr.
Gordon's Specialty Co.
Governair Corporation
Clinton O. Gowan, Jr.
Gowan Sheet Metal Inc.
Arthur D. Gowan
Gowco Incorporated
Grant Air Conditioning Company
Grant Technical Services
James R. Graves
J.R. Green Company, Inc.
Bud Griffin & Associates Inc.
Grunewald Engineering Inc.
Guardian Service Company
Harvey Guice Engineers Inc.
The Ken Gurry Corporation
John J. Guth & Assoc. Inc.
William K. Hall & Company
Hall Mechanical Contractors Inc.

David G. Halley & Co., Inc.
Hallmark Air Conditioning Inc.
Hambrick-Ferguson Inc./Tulsa
Hambrick-Jones-Ferguson
  & Associates/Oklahoma City
Hardcast Incorporated
Harrison-Orr Air-Conditioning Inc.
Harriss-Jambor and Associates
Michael N. Hart
Douglas Hayes
Weldon W. Henderson
Charles G. Heyne & Co., Inc.
Higgins & May Inc
J.D. Higgins Company, Inc.
Holland Equipment Company
Hollingsworth & Jackson Inc.
James B. Hollowell, Jr.
Alfred H. Hollowell
Fred R. Holste and Associates
  Consulting Engineers
Holt Insulation Inc.
Hou/Con International
Houston Chapter/ASHRAE
Houston Lighting & Power Co.
Houston Natural Gas Corporation
Houston Sheet Metal
  Contractors Association
Houston Trane Inc.
Howell-Stone Insurance Inc.
W. Hutson Company
Hydro-Air Incorporated/Dallas
Ideal Engineering Inc.
Industrial Htg. & Plpg. Co.
  of St. Joseph, Missouri
Industrial Roofing and Sheet
  Metal Works Inc./Shreveport
Jaco Sales Incorporated
Harold James Incorporated
Harold James
Jamesco Incorporated
  Mechanical Contractors
Jaycee Sales Corporation
Jochen & Henderson Inc.
Curtis H. Jochen
Kay Engineering Co.
  Oklahoma City
Key Heating and
  Air Conditioning Inc.
Torry King Incorporated
Leroy R. Klein, Jr., P.E.
Koldaire Supply Company
L & N Sales Company
LaMatt Agency Inc./Jacksonville
W.L. Lashley & Associates
  Houston
Lee & Browne
  Consulting Engineers Inc.
Lennox Industries/Ft. Worth
Lepco Inc. of Houston
Lewis & Lambert
Little Rock Mechanical Inc.
Lazcano Consulting
  Engineers Inc.
Lone Star Gas Company/Dallas
Lone Star Gas Co./Ft. Worth
Lone Star Gas Energy
Luckinbill Incorporated
M & M Manufacturing Co.
MCC Powers/Dallas
MM Environmental Eqpt. Co.
Robert Madden Inc.
Magill-Cloyd Engineers Inc.
Marshall/Trim-Aire
Mason-Dallas Incorporated
Matherly Mech. Contractor Inc.
George E. Maxwell
John B. May & Company, Inc.
Bob A. McAlister
McCroskey Sheet Metal Inc.
McIntosh Company, Inc.
McMillan Equipment Co.
Faye C. McQuiston
Mechanical Industrial Supply Inc.

Mechanical Industry
  Advancement Fund
Mechanical Representatives
  Inc./Austin
Mechanical Representatives
  Inc./San Antonio
Mechanical Sales Co.
  Oklahoma City
Mechanical Services Inc./Atoka
Mechanical Systems Balance
George H. Meffert
Mehlburger Tanner &
  Associates Inc.
Julio Melgar
Meridian Sheet Metal
  Roofing Company, Inc.
Midwest Insulation & Material Co.
Miller Technical Services
James W. Miller
Millis & Company, Inc.
Mitchell Technical Sales Inc.
James L. Mitchell
The Mogul Corporation
Mosby Mechanical Co., Inc.
Nabco Mechanical and
  Electrical Incorporated
Nation-Wide Insulation
Natkin & Company/Englewood
Natkin & Company/Tulsa
Nesbitt Engineering
Noland Company
  North Little Rock
O'Connell Robertson &
  Grobe Inc.
Oberkampf Supply of
  Lubbock Incorporated
Offshore Mech. Systems Inc.
Oklahoma Gas & Electric Co.
  Oklahoma City
Oklahoma Natural Gas Co.
  Oklahoma City
Oklahoma Natural Gas Co./Tulsa
Oslin Nation Company
P & S Associates Inc.
PVI Industries Inc.
Packaged Systems
Palmer Plumbing, Heating
  & Air Conditioning Co.
Paschal-Harper Inc./San Antonio
Persons-Howell Engineering Inc.
Pettit & Pettit
  Consulting Engineers Inc.
Pfeifer Plbg. & Htg. Co., Inc.
Philips Industries Inc.
Charles A. Phillips III
Charles E. Phillips
Pickens-Bond Construction
Pine Bluff Htg. and
  Air Conditioning Inc.
Pitts Engineering Company
James L. Pitts
Plumbing-Heating-Cooling
  Industry Promotion Fund
  Oklahoma City
James L. Powell
Power Eqpt. Co. of Memphis
Precise Sheet Metal Inc.
John Prince Company
Process Equipment Co., Inc.
Process Equipment Company
Public Service Co. of Oklahoma
  Tulsa
Pumps Unlimited
Purdy-McGuire Inc.
R & M Mech. Contractors Inc.
RIP Incorporated
Radalec Incorporated
Rainey Engineering Inc.
Raynaud Engineering Inc.
Red River Supply Inc.
Refrigeration & Electric
  Supply Co.
Reid Associates/Ft. Worth

Richardson's Plumbing &
  Heating Air Cond. Co.
Riddick Engineering Corp.
C.A. Riner Company, Inc.
River City Mechanical Inc.
Romine Romine & Burgess Inc.
Joe T. Romine
Harry E. Rountree
John H. Rule, Jr.
S & H Refrigeration
SMACNA/North Texas
San Antonio Plumbing &
  Pipefitting Industry Fund
San Antonio Sheet Metal
  Industry Fund
E.T. Saunkeah Company
Schmidt Plumbing Company
Schuelein & Halpain
  Engineering Inc.
Scott Air Cond. Co., Inc.
Seismograph Service Corp.
Semco Manufacturing Co.
  Little Rock
Service Plumbing Supply Co.
Shannon Engineering Co.
Sheet Metal Industry Fund
  of Western Oklahoma
  Oklahoma City
Sheet Metal Service
  Oklahoma City
Sheet Metal Specialists Inc.
  Oklahoma City
Shreveport Chapter/ASHRAE
Sigler Sales & Service
Simpson Technical Sales Co., Inc.
Skihl Enterprises Inc.
Smith Duncan Zijderveld
  and Associates Inc.
Smith Mech. Contractors Inc.
Snook & Aderton Inc.
Southern Sheet Metal Works
Ronald J. Spencer
Warren A. Spofford
Paul Sprehe & Associates Inc.
Stacy Engineering
Albert Sterling & Assoc.
H.E. Storer Incorporated
Streets Incorporated
  Mechanical Contractors
Sunbelt Mechanical
Suttler Madget Dabney Inc.
Swanda Brothers Inc.
T.D. Industries
Tacon Mechanical Inc.
Talex Engineers Inc.
Temtrol Incorporated
Tersco Incorporated/Ft. Worth
Tersco Inc. of West Texas
Texas Distributors Inc./Lubbock
Texas Electric Service Company
Texas Energy Engineers Inc.
Texas Power & Light Co.
Thermal/Mechanical
  Sales Co., Inc.
Bruce Thornton Air Cond. Inc.
3/D International Inc.
Timberlake & Wofford Inc.
Time Energy Systems Inc.
Trane Dealer Products Group
Trane Little Rock Sales Agency
Milton W. Trojan
Joe O. Tucker
Tulsa Trane Service Agy.
Tyler Refrigeration
United Mechanical Contractors
  Incorporated/Oklahoma City
United Mobile Aire Inc.
VBE Incorporated
Virginia Chemicals Inc.
Wade Company
Sam P. Wallace Co./Fort Worth
Sam P. Wallace Co. Inc./Houston
Sam P. Wallace Co./Tulsa
George Warren Company

HONOR ROLL INVESTORS IN ASHRAE RESEARCH 1983-84

Watt Plbg. Htg. Supply Co.
Wattie Wolfe Company
Waugh Brothers Supply Co.
Welco Sales Incorporated
West Texas Mechanical Inc.
Wickline Sales Company
R.L. Williams Company, Inc.
E.O. Wood Company
Yandell & Hiller Inc.
York Division, Borg Warner Houston
Young Sales Corporation
Zimmerman Incorporated

Region IX

Investments of $100 and more

Abeyta Engineering Consultants Inc.
Action Air Incorporated
Air Conditioning and Heating Service Company
Air Conditioning Systems Inc.
Air Filter Sales and Service/Denver
Air Purification Company
Air-Side Components
Airefco Incorporated
Allison Engineering Inc.
Raymond G. Alvine & Assoc.
Charles G. Arnold
Associated Mech. Industries Inc.
Atkinson Electronics
Aztech International Ltd.
BHCD Engineers Inc./Denver
Barnett & Company
Barnhart-Taylor
Kenneth K. Bastian & Associates
Beeson-Johnson Associates Inc.
Benton Corporation
Big Sky Chapter/ASHRAE
Bishop & Associates
Black Hills Area Chapter/ASHRAE
Black Hills Power & Light Co., Inc.
Blue Flame Gas Association of Nebraska/Omaha
Bob's Testing & Balancing Co.
Bowen Company, Inc.
J.H. Bowman Co., Inc.
Bridgers & Paxton Consulting Engineers Inc./Albuquerque
Ted R. Brown & Associates Inc.
Bryant Htg. and Air Cond. Co.
George E. Butler & Assoc. Inc.
C & C Sales Incorporated
CBA Company
CCI Mechanical
CFM Company
CTA Architects and Engineers
Carrier Distributing Co./Omaha
W.M. Carroll & Company
Cator-Ruma & Associates Co.
Central Air Conditioning Co., Inc.
Central Supply Co. of El Paso
City Wide Heating and Cooling Incorporated
Climate Equipment Company
Cobb Plumbing & Heating Co.
The Coleman Co. Inc./Wichita
Commercial & Industrial Insulation Incorporated
Commercial Air Management
Con'eer Engineering Inc.
Conservation Mechanical Systems Inc.
Contract Administration Fund of Colorado
Control and Equipment
Control Services Inc.
Copeland Powell & Moran
Crane Supply Company/Wichita
Creston Sales Company
DEN Management Company, Inc.
Leo A. Daly Company
Dana Larson Roubal & Associates
Dunham Associates Inc.
E & M Sales Incorporated
EMC Engineers Inc./Denver
Economy Mechanical Industries of Colorado/Denver
El Paso Pipe & Supply
The Electric Company
Energy Balance Inc.
Engineered Control Systems Inc.
Engineered Equipment Company Incorporated/Lenexa
Engineered Products Co./Denver
Engineering Consultants Inc.
FM Incorporated
The Fagan Company/Kansas City
John C. Fasnacht
Felts-House Engineering Inc.
Four Seasons Engineering Ltd.
Fry Equipment Co., Inc.
GCS Control Systems Inc.
Gartner & Associates Co., Inc.
Gas Company of New Mexico
The Gellert Company
General Heating & Cooling Co./North Kansas City
Goodwin Engineering
J. Barrie Graham
Grider-Robinson & Assoc.
Griffith Engineering Service
Gritton & Associates Inc.
Robert E. Hahn
Heath Engineering Company
Henningson Durham and Richardson/Omaha
Henthorn Sandmeyer & Co. Consulting Engineers
Herlin Equipment Co. of El Paso
Howard-Needles-Tammen & Bergendoff
Larry W. Howe
William C. Howe
Hughes Machinery Company
Huxtable-Hammond Co., Inc. Shawnee Mission
Idaho Chapter/ASHRAE
Idaho Power Company
Industrial Air Systems/El Paso
Stephen W. Ivesdal
J & J Register Co., Inc.
JL Mechanical Company
James Cooke & Hobson Inc.
The Johnston Company
Charles D. Jones & Company Kansas City
Charles D. Jones Company Denver
Jorban-Riscoe Associates Inc.
EW Juneman Sales Company
KN Energy Incorporated
Kansas Air Conditioning Contractors Association
Kansas City Chapter/ASHRAE
Kansas City Power & Light Co.
Kansas Gas and Electric
Kendall Incorporated
Kice Metal Products Co., Inc.
Robert L. Kilker
Kirkham Michael & Assoc. Inc.
Weldon F. Kite Company
Frederick Kohloss & Associates Inc./Wheat Ridge
Krier & Blain Inc.
Pete Lien and Son Inc.
Long & Associates Inc.
Long-Deming Utah Inc.
Lucas Company Inc.
Maniktala Associates P.C.
Marcum Incorporated
Marley Cooling Tower Co./Denver The Marley Fund
The Marley Fund/Mission
Ray Martin Company of Omaha Mechanical Contractors
A.A. Maycock Company, Inc.
McCoy Sales Corporation
McElroy's Incorporated
McFall-Konkel & Kimball
Lawrence J. McLain
McLemore Pump Inc.
McNevin Company
Mechanical Consultants Inc.
Mechanical Contractors Association/Omaha
Mechanical Contractors of Kansas City
Mechanical Representatives Inc. Albuquerque
Mechanical Sales Inc./Omaha
Mellen & Associates Inc.
William G. Menzel
Metal-Fab Incorporated
Mid-States Supply Company
Midgley Huber Inc.
Midland Mechanical Inc.
Midwest Engineering Service Inc.
Midwest Insulation Contractors Association of Nebraska
Midwestern Insulation Contractors Association of Wichita Inc.
Miller Metal Company, Inc.
Missouri Public Service Company
Robert L. Moore Company, Inc.
Mountain Fuel Supply Co.
Mountain Standard Sales Inc.
Musgrove Engineering
National Heating & Vent. Co., Inc.
Natkin & Company/Englewood
Natkin & Company/Kansas City
Natkin & Company/Omaha
Natkin Service Company/Wichita
Nebraska Chapter/ASHRAE
New Mexico Pipe Trades
Northern Natural Gas Co.
O'Connor Companies Piller Foundation
The O'Connor Company
Alex J. Occhionero & Associates Incorporated
Olsen & Peterson Consulting Engineers Inc.
Gene Oswald Company
Pacific Pumping Company Oakland
Pasterkamp Heating and Air Conditioning Company
Leroy E. Petersen Company
B.G. Peterson Company
Petterson Associates Inc.
Philips Industries Inc.
N. Pitlor & Son Inc.
M.J. Poland Associates
Preston Refrigeration Co., Inc.
Professional Engineering Consultants P.A./Wichita
Professional Engineering Co. Omaha
Public Service Company of New Mexico/Albuquerque
Pump Technology
R & S Balancing Company
RKR Corporation
The RMH Group Inc.
Redlinger Brothers
Refrigeration Equipment Co.
Reinhardt Brothers Inc.
Richardson Equipment Co.
Robinet and Associates Consulting Engineers Inc.
Charles K. Robinson
William F. Robinson
Roby Quintal & Everson Consulting Engineers
Rocky Mountain Air Inc.
Rocky Mountain Mechanical and Electrical
Rocky Mt. Chapter/ASHRAE
Roto Air Filter Sales and Service
SMACNA/Kansas City
SMACNA/Montana
Sabol & Rice Inc./Salt Lake City
Sabol & Rice of Idaho Inc.
The Salina Supply Company
Service Supply
Sheet Metal Contractors Industry Fund/Salt Lake City
Sheet Metal Workers Local Union #49/Albuquerque
Verne Simmonds Company
South Dakota Chapter/ASHRAE
Laurance S. Staples Jr.
Sun Manufacturing Inc.
Superior Boiler Works Inc.
Superior Supply Company, Inc.
Carl A. Swenson
T & B Services Inc.
TSP Incorporated/Sioux Falls
Temperature Control Inc. Albuquerque
Tempmaster Corporation
R.L. Tenney & Sons Inc.
Tessier Sheet Metal Works Inc.
Thermal Components Co.
Thermal Equipment Company/Salt Lake City
John Thompson and Assoc. Inc.
Tolin Refrigeration Co.
The Trane Company/Omaha
Triangle Sales Inc.
U.S. Engineering Company
U.S. Supply Company/Wichita
Utah Chapter/ASHRAE
Utah Power & Light Co.
Van Boerum & Frank Assoc. Inc.
Van Doren-Hazard-Stalling Architects-Engineers
W.L. Van Ert Company, Inc.
Viro Con Incorporated
WA-CO Heating and Air Cooling Inc.
The Waldinger Corporation
The Walling Company
Weathercraft Plumbing Co.
Weber & Associates Inc.
Weidman Company
Western Energy Control Inc.
Western Engineering
Wichita Burner Co., Inc.
Wichita Chapter/ASHRAE
J. Wilcox Company
The Williams Engineering Co.

Region X

Investments of $100 and more

A & A Mech. Contractors Inc.
ACR Mechanical Corp.
Acutron Company Inc.
Air Balance Company of Nevada/Las Vegas
Air Conditioning Company Incorporated/Glendale
Air Conditioning Specialties Company Inc./Fullerton
Air Conditioning Supply Company/Carson
Air Conditioning Supply Company/Honolulu
Air Engineering Co., Inc.
Air Filter Control Inc. South San Francisco
Air Filter Service Co., Inc.
Air Treatment Equipment Corp.

Ajax Boiler Incorporated
Allied Air Inc./San Ramon
Anderson de Bartolo Pan Architecture & Engineering
F.T. Andrews Incorporated
ASHRAE Headquarters
Associated Air Conditioning Inc.
AU's Plumbing & Metalworks Inc.
Authorized Supply Corp.
Bac-Pritchard Inc.
Baltimore Aircoil of California/Madera
Beam Engineering Inc.
J.P. Beecher & Associates Inc.
Bemco Incorporated
Brown Zammit Enyert Engineering Inc.
Horace E. Burrier
Cal-Air Conditioning
California Hydronics Corp.
Carrier Hawaii
Central Arizona Chapter/ASHRAE
Ceramic Cooling Tower Co. Huntington Beach
Cedric D.O. Chong & Assoc. Inc.
Clemco Pacific
Climatec Incorporated
Commercial Refrigeration Co.
Commercial Sheetmetal Co., Inc.
Continental Mechanical of the Pacific Inc.
Cosgrove Lowrie and Cleveland/Phoenix
Don Cross Sales Company
DMG Corporation
Dahl Taylor & Associates Inc.
Daniel Mann Johnson and Mendenhall
Theo Davies Energy Systems
Dinwiddie Construction Co.
Donaldson Power Ventilation Co.
W.L. Donley & Associates Mechanical Engineers
Joe S. Earhart
Eco-Air Products Inc.
Energy Optimization Inc.
Engineered Automation Systems Inc.
Environmental System of Arizona Inc.
Environmental Systems Inc.
David S. Falk Company/Phoenix
Farr Company/El Segundo
Harold Feldstein
Ferris & Hamig Hawaii Inc./Honolulu
Feuer Corporation
Gardner Engineer Inc.
Gayner Engineers
Golden Gate Chapter/ASHRAE
George A. Greene Company Consulting Engineers
Gurries & Okamoto
HGP
HP Associates Inc.
Haldeman Incorporated Los Angeles
George E. Haney & Son Inc.
Theodor M. Hanft
Hansen Mechanical Contractors Sparks
Cyril G. Hansen
W.D. Harrison & Assoc. Inc.
Hawaii Sales Associates Inc.
Hawaiian Electric Co., Inc.
Hayakawa Associates Los Angeles
Heide & Cook Limited
Richard S. Heitz
Ray L. Hellwig Plumbing and Heating Company
Hess Greiner & Polland Los Angeles
Hess Greiner & Polland San Mateo
Hillcrest Mechanical Inc.
William L. Holladay
Honeywell Construction Division/Phoenix
Honolulu Painting Co. Ltd.
Louis G. Horsefield and Associates
B. Lee Hutchinson
ICOM Mechanical Inc.
J & B Salos Company
JBA Consulting Engineers/Las Vogas
JD Sales Company, Inc.
James C. Jones
Kamore Air Conditioning
Jim Y. Kanomata
Key Mechanical Industries
Kinney-Anaheim Division
J.A. Knowles & Associates
Kocher & Nishimura Inc.
Koenigshofer Engineers Inc.
Frederick H. Kohloss and Associates Inc./San Francisco
Frederick H. Kohloss and Associates Inc./Tucson
Frederick H. Kohloss and Associates Inc./Honolulu
Frederick H. Kohloss
Kruger Manufacturing Co.
LSW Engineers
J.P. Lamborn Company
Donald R. Lawrence & Associates Mechanical Engineers
Rodney K. Lawson
Dorvin Leis Company, Inc.
Lennox Industries/Fullerton
Levine/Seegel Associates
Karl J. Lillie
Liston & Thompson Inc. Mechanical Engineers
Gil Lord Associates
Lowry-Sorensen-Willcoxsen Engineering
Ludovise & Associates Inc. Consulting Engineers
R.F. MacDonald Company
Maier Incorporated Mechanical Contractors
Marley Cooling Tower Co. San Gabriel
Albert C. Martin and Associates
Peter J. McCarty
J.W. McClenahan Company
McClintock & Bustad Inc.
Mechanical Engineers of Hawaii Corporation
Mechanical Planning Inc.
Mechanical Supply Inc. Sacramento
Mechanical Systems Corporation
Peter I. Menconi
J.L. Meyers Company
Mirov-Trane Service Agency
Montgomery & Roberts Construction Engineers
John Allen Morse A/C Specialties Co.
Randolph Murayama & Assoc.
Hayward G.S. Murray
Natkin & Company/Santa Clara
James G. Nemechek
Nevada Power Company
Nevada Supply Inc.
Oahu Air Conditioning Co. Honolulu
Orange Empire Chapter/ASHRAE
Pacific Industrial Distributors Inc.
Pacific Resources Inc.
Paco Pumps
Emil M. Pahor Air Conditioning & Sheet Metal Contractors Inc.
Pahor Refrigeration & Air Conditioning Services Inc.
Richard A. Palmer & Associates
Park Mechanical Inc.
John D. Peck
Leroy L. Peters
Ralph E. Phillips Inc.
Plumbing & Air Conditioning of Arizona Tucson Area Inc.
Plumbing-Heating-Cooling Contractors Industry Promotion Fund
Polyaire Mechanical
Polycold Systems Inc.
Potoroff Company Inc.
Power Systems Associates
Quality Air Conditioning Las Vegas
Rapid Mechanical Contractors Inc.
Raypack Incorporated
Redwood Mechanical Plumbing Co., Inc.
Refrigeration Supplies Distributor Monteray Park
Reglen Systems Balance Inc.
David B. Rodkin
Rodoni Becker Company, Inc.
SMACNA/Northern Nevada
SMACNA/San Jose
SMACNA/Tucson
SMACNA Industry Fund
Sacramento Piping Industry Fund
San Diego Chapter/ASHRAE
San Jose Chapter/ASHRAE
Joseph H. Schauf Company Inc./Campbell
Sierra Pacific Power Co.
Slakey Brothers Inc.
Soska & Associates
Southern California Edison Co.
Southern California Gas Co.
Southern California Chapter/ASHRAE
Southern Nevada Chapter/ASHRAE
Southwest Air Conditioning Inc.
Southwest Gas Corp./Las Vegas
Specialty Products Inc.
Carroll G. Stark & Assoc., Inc.
Merle Strum & Assoc., Inc.
Syntech Limited
Syska & Hennessy/San Francisco
Syska & Hennessy Inc. Culver City
T & M Mechanical Sales Co., Inc.
Charles B. Taylor
Tenaire Incorporated
Therma Air Conditioning Co.
Thermal Mechanical Heating & Cooling Contr./Santa Clara
Thermal Products Co./Cerritos
Kenneth Thom Associates Ltd.
Thorpe Insulation Co. Los Angeles
Thorpe Insulation Co./San Diego
Toro Aire Incorporated
The Trane Company/Las Vegas
Trane Pacific Service/Honolulu
Tucson Electric Power Co.
University Mechanical
Valley Supply Incorporated
Valley Trane Service
John A. Vincent
Vossler Company
Gary Walker & Assoc.
Sam P. Wallace Company of Southern California
Edward B. Ward & Company
Dana E. Washburn
Westates Pacific Co., Inc.
Western Air and Refrigeration Company, Inc.
Western Allied Corp.
Western Allied Corp.
Western Nevada Supply Co.
Verle A. Williams and Associates Incorporated
M. J. Wood & Associates Inc.
Norman S. Wright Co./Phoenix
G. J. Yamas Co., Inc. South San Francisco
Yamoto Engineering
John I. Yellott
York Division, Borg Warner Corp./Cerritos

Region XI

Investments of
$100 and more

Action Consulting Engineers
Adams Morgenthaler & Co.
Air Filter Sales and Service/Portland
Air Movement & Mechanical Services Limited/Winnipeg
Airmaster Sales Ltd./Winnipeg
Airtherm Engineering Sales Ltd.
Alaska Mechanical inc.
Alaska Winter Inc.
American Heating Company, Inc.
Arco Enterprises and insulation Limited
J. M. Bean & Company Ltd.
Betco Limited
Kurt Bittlingmaier Associates Inc.
Bonneville Power Administration
Botting Mechanical Ltd. Saskatoon, Saskatchewan
The Bowling Company
Brod & McClung-Pace Co.
Brown Strachan Associates
Angus Butler Engineering Ltd.
The Cambrian Engineering Group Ltd.
G. J. Campbell & Associates Seattle
J. K. Campbell and Associates Ltd./Edmonton Alta
R. W. Campbell Incorporated
Canadian Western Natural Gas Company Ltd.
Carson Bekooy Gulick and Associates Incorporated
Century Mechanical Ltd.
Climate-Tec Incorporated
Cole Industrial Incorporated
Comstock International Ltd. Regina
Conley & Company Contractors
E. S. Constant Company
Contract Mechanical Ltd.
M. E. Cook Mechanical Ltd.
William R. Course
Crane Supply—Regina
Crews MacInnes Hoffman/Vitro
Cross Control Systems
Daniels Engineering Ltd.
Dean Consulting Engineering Ltd.
Dent Holdings Limited
Dominion Construction Co., Ltd.
Enstar Natural Gas Company
Eugene Water & Electric Board
Fairview Sheet Metal Work Ltd.
Fennell Cochsane Navalin
Fryer/Pressley Engineering
Robert L. Gamble
Roy L. Gamble
Gaylord Industries Inc.
Gibson Company
John Graham & Company/Seattle
George H. Green
HVAC Sales Ltd./Regina
Halvorson Beach and Bower Inc.
C. J. Hansen Company, Inc.
Larry Harrington Co., Inc.
Hewlett Packard
Holaday-Parks Fab Inc.
Honeywell Incorporated/Bellevue
Honeywell Limited/Regina

HONOR ROLL INVESTORS IN ASHRAE RESEARCH 1983-84

C. M. Hoskins Company, Inc.
Industrial Power Installations Edmonton Ltd.
Inland Natural Gas Co., Ltd.
Interface Engineering Inc.
Isotec Limited Consulting Engineers
Johns-Manville Canada
Johnson Controls/Regina
Johnson Controls/Toronto
Johnson-Barrow Inc.
Jones Food Store Equipment Ltd.
K. D. Engineering Company
Kaiser Engineers Hanford Co.
Keen Engineering Co., Ltd. Victoria
Keen Engineering Co., Ltd. Regina
Dennis D. Kiselbach Ltd.
Klassen Angus Group Ltd.
Edward Kovarik
J. R. Kowalishin Sales Corp.
Jerry W. Kruk
Lamb McManus Associates Ltd.
Godfrey J. E. Lamble
Lockerbie & Hole Co., Ltd.
Luhn Shafer & Luhn Engineers
MCW Consultants Ltd./Winnipeg
MCW Consultants Ltd.
MacDonald-Miller Company
Joseph I. Mandley
The Massart Company
Charles W. Mathisson
McCartan Gaudet and Associates Ltd.
McDougall Control Co.
McPherson Supply Company
Mechanical Equipment Western Winnipeg
Mechanical Sales Inc./Seattle
Mecon Sales (1980) Limited
Mid Columbia Chapter/ASHRAE
Morrison Funatake Induye Andrews Inc.
W. Bruce Morrison
Mortemp
Sydney Narvey
Nor-Air Incorporated
Norby Company
Northern Blower Canada
Northwest Engineering Service Inc.
Northwest Natural Gas Co.
Northwest Pipeline Corp.
Oregon Chapter/ASHRAE
Perry Engineering Ltd.
Peterson Associated Engineers Incorporated
Plumbing and Mechanical Industry Promotion Fund for Anchorage
Portland General Electric Co.
Proctor Sales Inc./Anchorage
Proctor Sales Inc./Seattle
Puget Sound Pipe & Supply Co.
Puget Sound Power and Light Co.
Queen Pump Company
R-G Sales Company Ltd.
Refrigeration & Air Conditioning Assn. of British Columbia
Regina Chapter/ASHRAE Energy Management
Reid Crowther & Partners Ltd. Calgary
Reid Crowther & Partners Ltd. North Vancouver
Ian T. Ross
Roto Air Distributors Canada Ltd.
SMACNA Western Washington Sheet Metal Industry Fund
Saskatchewan Insulation Contractors Association
Saskatoon Boiler Manufacturing Company Ltd.
Saskatoon Mechanical Contractors
Selmec Engineering Ltd.
James P. Sheldon Company
Skoglund Company Inc.
Paul K. Skoglund
Southern Alberta Chapter/ASHRAE
Square M. Engineering Ltd.
Richard M. Stern
M. A. Stewart & Sons Ltd./Surrey
Streimer Sheet Metal Works Inc.
Summit Engineering Sales/Calgary Limited
Superior Plumbing and Heating
TRA Architecture Engineering
Temp-Control Corporation
D. W. Thomson & Consultants Limited
C. W. Timmer Associates Inc.
Total Mechanical
Trane Company Limited/Calgary
Trane Service Agency/Winnipeg
Tri-Metal Fabricators Ltd.
Trotter & Morton Limited
Underwood McLellan Ltd.
United Ventilation and Air-Conditioning Ltd.
University Mechanical Contractors Inc.
Vinto Engineering Ltd./Calgary
Vinto Engineering Ltd./Vancouver
Vitro Engineering Corp.
W. L. Wardrop & Associates Ltd.
Washington Air Reps., Inc.
Washington Natural Gas Co.
The Washington Water Power Co.
Water Conditioning Canada Ltd.
Robert D. Wells
Welsh Cablevision Ltd.
Westburne/Regina
Western Air Cond. Ltd.
Western Mechanical Inc. Fairbanks
Western Mechanical Services (1977) Limited
Western Supplies Ltd.
Whittick Mechanical Contractors Limited
Wieland Lindgren & Associates
Yoneda & Associates Vancouver
Yoneda & Associates Ltd./Regina

Region XII

Investments of $100 and more

Able Products Company Mechanical Contractors
H. B. Adams Incorporated
Air Conditioning Associates Inc. Ft. Lauderdale
Air Conditioning Contractors Association of Central Florida
Air Conditioning, Refrigeration, Heating & Piping Assn., Inc.
Air Conditioning Equipment Inc. Fort Lauderdale
Air Enterprises Inc./Tampa
American Coolair Corporation
Aqua Air Products
Associated Air Products Inc.
Astron Mechanical Inc.
Atlantic Air Incorporated
B & I Contractors Inc.
Bailey & Associates Inc.
Ronald B. Bailey
The Bared and Company West Palm Beach
The R. H. Barto Company
Brabham Debay and Associates
Brantley Sheet Metal Co., Inc.
Braun Paschal and Associates
T. H. Brooks & Associates
M. G. Brophy Company, Inc.
Burnes-Woolley and Associates Inc.
Burton & Rolley Inc.
C & W Climate Control
Cadwallader Campbell and Associates Inc.
Carastro Aguirre and Associates Inc.
Todd Carey & Assoc. Inc.
Carroll Air Systems Inc. Winter Park
Carroll Air Systems Inc./Tampa
John C. Cassidy
Central Florida Chapter/ASHRAE
Chane Incorporated
Clark Equipment Company
Coastline Distributing of Riviera Beach Inc.
Codisco Incorporated
Commercial Products Corp.
Control Center Inc.
E. M. Corson & Associates Inc.
Couse Corporation
J. A. Croson Company
Daniel & Jones Sheet Metal Inc.
Davis & Kenyon Consulting Engineers
Dell Corporation
Denco Air Conditioning Inc.
Diversified Fluid Controls Inc.
Driggers & Associates Inc.
Engineering & Equipment Co.
Environmental Balance Inc.
Environmental Tech Inc., J. V. Associates
Eubanks Sales Company
F H P Manufacturing Division Leigh Products
Ferber S/M Works Inc.
Flanagan & Flanagan Inc.
Floreth Sales Corporation
Florida Air Conditioners Inc. Ft. Myers
Florida Air Conditioners Inc. Jacksonville
Florida Air Conditioners Inc. Clearwater
Florida Hydronics Inc.
Florida Power & Light Co./Miami
Florida Power Corporation St. Petersburg
Fla. Resid. Designers Assn.
Florida West Coast Chapter/ASHRAE
Brian G. Flynn
Flynn's Air Conditioning Inc.
Fox Insulation Company
Garrison & Sizemore Mechanical Contractors
W. W. Gay Mechanical Contractors Inc.
Gemaire Distributors Inc./Miami
Gemaire Distributors Inc. Deerfield Beach
Gold Coast Chapter/ASHRAE
Walter A. Grant
Graves Refrigeration Co./Miami
Grinnan Engineering Inc.
Gulfcoast Mechanical Inc.
H L M Engineers Inc./Orlando
Earl Hagood Incorporated
Harper Plumbing & Heating Co., Inc.
Hazen Trane Service Agency
Hill York Broward Management Co.
Honeywell Inc./Orlando
A. L. Hospers & Associates Inc.
Lyle M. Houser
Howard Trane Service Agency
Ingley Campbell Moses & Associates Inc.
George A. Israel, Jr., Inc.
Jacksonville Chapter/ASHRAE
Jacobs-Baker Associates Inc. Jacksonville
Jacobs-Baker Associates Inc./Largo
Maurice J. Jacobson
Jomac of Orlando Inc.
Jones & Associates
K C Air Conditioning Inc.
Edward F. Keller
Langbein & Bell Engineers Inc.
Liebtag Robinson & Wingfield Inc.
Lorenze & Associates Inc.
M S I Incorporated
Marion Maner Incorporated
Frank A. McBride Co. Jacksonville
McMichael & Assoc. Inc.
Mechanical Associates Inc.
Mechanical Contractors Association of So. Florida
Mechanical Insulating Co.
Mechanical Services Inc. of Orlando
Metal Industries Foundation Inc.
Mitco Water Laboratories Inc.
Modern Control & Supply Inc.
R V Money Incorporated
Munson & Associates Inc.
National Sheet Metal Co. Jacksonville
Norris Air Conditioning Inc.
James A. Oberlin, Mechanical Contractor/Maitland
Ossi Consulting Engineers Inc.
Palm Beach Air Conditioning Association Inc.
Everett P. Palmatier
Pipefitters Local Union No. 725
The Poole & Kent Company
Power Conditioning Inc.
Quality Air Conditioning Co. Ft. Lauderdale
Ray's Metal Works Inc.
R. Franklin Rhodes
Rogers Lovelock & Fritz Inc.
James E. Rose
Sauer Mechanical Inc.
Southeast Mechanical Contractors Inc.
Southern Equipment Corp.
Spence & Associates Inc.
Stolley & Associates Inc.
R. Douglas Stone & Assoc.
David A. Sturges
Tampa Electric Company
Test & Balance Corp. of Orlando
Test & Balance Corp./Tampa
Thermal Equipment & Sales
The Thompson Company
Tompkins-Beckwith Incorporated
David M. Totten Trane Co.
The Trane Company/Tampa
Trane Western Hemisphere Santruce
Tropic Supply Inc.
Turknett/MPS Engineers
U A Local Union No. 630
V F Air Systems Inc.
Van Wagenen & Beavers Inc.
Vickery-Clarke Inc.
Weatherking Incorporated
Stan Weaver & Company, Inc.
George S. Whittlesey, Jr.
Bill Williams Air Conditioning & Heating Inc.
Wright Superior Inc.

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Many contributions to ASHRAE Research are made to honor a member, business associate and friend. Individuals, chapters, companies and other industry organizations contributed to such memorials during 1983 and 1984. The gestures honor the members by continuing the work of the Society which they supported. There are no restrictions as to the amount contributed as a memorial. Recognition is accorded the individuals for whom such memorials have been established, as well as the individuals, chapters and organizations which have contributed to the memorial. Those being honored are listed in bold type. Contributors' names follow.

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  - John C. Cassidy Air Conditioning
  - Chane Inc.
  - E. M. Corson & Associates
  - Dalla Rizza & Associates
  - Diversified Fluid Controls, Inc.
  - Art Garbarino
  - Harlow & Associates
  - Orlando Hernandez
  - Inscho-Kirin of Florida, Inc.
  - Johnson Controls/Miami
  - Brad Kinggarde
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  - Frank Limpach & Associates
  - Dale M. Maloney
  - Robert A. McGreevy
  - Ralph D. McKee, Jr.
  - Chris Mills
  - Nick Pengamillis
  - Ralph Penna
  - Anthony Polino
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  - Associated Organic Marketing
  - Bendall and Company, Inc.
  - Energy Management Consultants
  - Harris Air Systems, Inc.
  - The Hardy Corporation
  - J. H. Judd Company, Inc.
  - W. C. Martin, Jr.
  - John P. McLarty
  - The Merrill Co., Inc.
  - Miller & Weaver Consulting Engineers
  - Palmer & Lawrence, Inc.
  - S. L. Pappas & Co., Inc.
  - Rowan & Associates, Inc.
  - Ladell M. Smith
  - Southeastern Refrigeration, Inc.
  - Steel City Wholesalers, Inc.
  - Paul G. White
- ***David J. Levine***
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  - Thomas S. Brown
  - William P. Chapman
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  - William J. Collins, Jr.
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  - Harold E. Faller & Associates
  - Frederick H. Kohloss
  - John I. Levenhagen
  - Preston E. McNall
  - Memphis Chapter/ASHRAE
  - Mechanical Construction Co. of New Orleans
  - George E. Millard, Jr.
  - Bruno Morabito
  - New Orleans Chapter/ASHRAE
  - Donald E. Nichols
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  - Thomas J. White
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- ***Edwin Paplanus***
  - Philip Dreifuss
- ***Carl W. Price***
  - National A & R Supply
- ***William Rudoy***
  - J. Richard Wright
- ***Joseph Simons***
  - C. Lee Babin
  - Mr. & Mrs. Robert W. Briggs
  - T. Ronnie Butler
  - Guy De Feo Company, Inc.
  - C. N. Flagg & Company, Inc.
  - Robert C. Gould
  - Richard M. Graves
  - George Holzworth
  - Allen Hubbard
  - Janazzo Heating & Air Conditioning, Inc.
  - Evert M. Johnson
  - Nortec Industries, Inc.
  - P. G. Perrotti & Assoc.
  - Quinlan & Giannoni, Inc.
  - Savage Engineering, Inc.
  - Robert D. Upton
  - Skuttle Manufacturing Company
  - Wesson Heating and Air Conditioning Corp.
- ***Lee Thompson***
  - Gowan Sheet Metal
- ***J.W. Tidwell, Jr.***
  - Southern Sheet Metal Works
- ***Earle K. Wagner***
  - William P. Chapman
- ***Daniel D. Wile***
  - ASHRAE, Inc.
- ***Chet Winn***
  - Halvorson, Beach & Bower, Inc.
  - James & Shirley Halvorson
  - Honeywell, Inc./Bellevue
  - C. M. Hoskins Co.
  - Al Wilcox Co., Inc.
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ASHRAE

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

Energy Policy

Approved by the Board of Directors
February 2, 1984

Preamble

As stated in its Bylaws, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) is organized and operated for the exclusive purpose of advancing the arts and sciences of heating, refrigeration, air conditioning and ventilation, the allied arts and sciences, and related human factors for the benefit of the general public, and to fulfill its role, the Society shall recognize the effect of its technology on the environment and natural resources to protect the welfare of posterity.

Energy resources are a fundamental ingredient of all economic systems. They are essential to the defense of nations, necessary to feed the world's populace, and vital for our protection from the elements. The conversion of these resources from their natural states to end-use energy forms is a science known and practiced by the engineering profession. For this reason, ASHRAE will expend every possible effort to develop the knowledge necessary to address the energy problem, to disseminate this knowledge, and to assume a leadership role in these efforts.

Recognizing that the world's energy goals can be reached only through aggressive and unrelenting cooperative effort involving all segments of society, and consistent with the needs, aims and aspirations of the international community, ASHRAE, aware of its mounting responsibilities, has adopted the following energy policy:

The ASHRAE Energy Policy is to develop and distribute technical knowledge for design, application, installation and operation of energy efficient heating, ventilation, air conditioning, and refrigeration with due regard for human health, comfort and environmental quality.

In the implementation of this policy, the Society recognizes the need for adopting positions and for international exchange of energy conservation technology and will:

(1) Identify, encourage and conduct research for improving the efficiency and effective use of energy systems and equipment.
(2) Continue the development, improvement or identification of voluntary, consensus standards that will increase the efficiency of energy use in buildings, systems and equipment.
(3) Address the quality of the indoor and outdoor environments while recognizing the need to provide for human health in the efficient use of energy.
(4) Identify and encourage the development of methods, systems and equipment which improve the effective use of renewable energy resources.
(5) Increase awareness of the general public in the value of the selection and effective use of energy-efficient buildings, systems and equipment.
(6) Develop more effective means of communicating within the industry the knowledge and motivation necessary to improve techniques for designing, installing and operating energy-efficient equipment and systems.
(7) Participate at all levels of government in the formulation of policies, laws and regulations relating to the efficient use of energy resources in buildings, equipment and systems.

ASHRAE Energy Policy

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The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) is a non-profit organization operated to advance the arts and sciences of heating, refrigeration, air conditioning and ventilation, the allied arts and sciences and related human factors for the benefit of the general public. Founded in 1894, it consists of some 50,000 members from around the world. The Society maintains headquarters in Atlanta, Georgia, and an office in Washington, DC.

ASHRAE
American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc

AMERICAN SOCIETY OF HEATING,
REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.

Position Statement on Indoor Air Quality

Approved by the Board of Directors
July 1, 1982

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Prepared by the ASHRAE Ad-Hoc Committee on Indoor Air Quality

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AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.

Position Statement on Indoor Air Quality

Executive Summary

Approved by the Board of Directors July 1, 1982

The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) is concerned with the technical means for the conditioning of the indoor environment and with the definition and creation of economically optimum conditions within that environment while minimizing adverse effects on the outdoor environment.

While progress has been made in improving the quality of outdoor air, indoor environments in which we spend 90 to 95 percent of our time have been neglected by comparison. Large increases in energy costs have caused a reduction in ventilation to conserve energy, and new materials that often emit pollutants are being continually introduced into buildings. Both of these developments result in increased levels of contaminants in the indoor environment.

Recommendations

ASHRAE believes that private interests alone cannot perform the research to identify problems and develop the generic means for their solutions. It is in the public interest to quantify the health risks associated with air contaminant exposures encountered indoors. Cost-effective and efficient means of reducing the health risks must be identified. Public policy options for maintaining and improving the air quality of indoor spaces must be developed. Once the research has identified needs for better solutions for improved health, ASHRAE believes the private sector will respond to the needs with improved, innovative, cost-effective solutions.

The quality of indoor air is influenced by outdoor air quality, building structure, building materials, consumer products, appliances, occupant activities, etc. Government, industry, professional societies, and individuals all share in the responsibility for the quality of indoor environments.

While some incentives do exist in the private sector to conduct research and develop products related to indoor air quality, ASHRAE believes that government has an important leadership role to sponsor research on indoor air quality, its human health consequences, and to advance the technology of contaminant control. This is not exclusively a governmental function. ASHRAE recognizes its responsibility through its own sponsored research, standards, publications, and meetings. However, no single professional society, manufacturing association, trade association, or branch of industry has the comprehensive interest, resources and competence in indoor air quality technology to insure that a well-funded systematic research program is conducted.

Specific actions follow:

1. Government-supported health effects research should be substantially increased and designed to determine the physiological and toxicological effects of specific contaminants that are known to be present in indoor environments. This research should, as a minimum, involve:
   - a. clinical exposure studies and animal studies as well as occupational health effects research;
   - b. prospective epidemiologic studies that identify populations and follow them in time with detailed environmental and physiological measurements;
   - c. identification of sensitive individuals in society and the investigation of possible subtle neuro-toxicological effects of specific contaminants.

These research programs should include the effects of both chemical and biological contaminants.

2. A government-supported national inventory of indoor air contamination should be undertaken. The goal of this comprehensive program would be the identification of populations at risk to potentially hazardous levels of indoor air pollutants. The components of this inventory would include surveys of air exchange rates, sources of indoor air pollutants such as building materials, consumer products, combustion devices, and the resulting pollutant concentrations. The development of

mathematical models of the interactions among indoor air pollutants, air exchange rates, and energy consumption will be needed. The development of additional reliable and sensitive portable monitoring equipment will often be necessary. The importance of indoor air pollution to populations identified at risk should be determined by evaluating the total pollutant exposure to individuals and the contributions of indoor pollutants to this exposure.

ASHRAE believes that this rational program should first address the potential hazards resulting from indoor exposures to radon, asbestos fibres, unvented combustion products, formaldehyde, and tobacco smoke and chlorinated organic chemicals.

3. Available information, as well as information developed under items one and two above, should be continuously evaluated in the context of guidelines for indoor air quality with the goal of revising suggested ventilation standards and other control strategies. Government should collaborate with the appropriate professional societies such as ASHRAE in these endeavors.

4. However, even before new health and/or exposure data are available, ASHRAE recognizes that there are a number of acute indoor air quality problems which may require immediate remedial actions. Educational, technical, legal, and if necessary, financial assistance should be provided through appropriate state or municipal agencies. The Federal government should assist states in developing and supporting these capabilities on local levels.

5. ASHRAE Standard 62-1981, "Ventilation for Acceptable Indoor Air Quality," is the most comprehensive current ventilation standard recognizing the balance between the needs to conserve energy and to provide for human health. This standard updates the ventilation standard of 1973, ASHRAE Standard 62-73, "Standards for Natural and Mechanical Ventilation," which is now widely incorporated or referenced in state and local mechanical building codes. Where legislation is pending, ASHRAE Standard 62-1981 should be considered for incorporation into the various state and local codes. This will promote energy savings while further research proceeds. New research results will be used to revise the ASHRAE Standard in the future, under the existing ASHRAE procedures.

6. Where a reduction of indoor air pollution levels is indicated, the policy options under which such reductions may be encouraged need to be examined. These include the market forces, source control, manufacturing controls, and property and operational regulations, as well as establishing and enforcing standards.

7. The private sector, including professional societies like ASHRAE, should be involved in improving products, performance standards for instruments, materials, equipment, and entire heating, ventilating, and air-conditioning systems and their controls, as well as enhancing the professional practices of its members.

8. The dissemination of technical information among professional societies and to the public is an important function of organizations such as ASHRAE. Agencies of government can assist in this effort through the joint sponsorship of research, publications, and conferences.

9. Because indoor air quality is of particular interest to ASHRAE, its substantial program on research and standards development for ventilation requirements and product performance will be increased. In addition, ASHRAE will actively encourage its members to participate in the development and implementation of local building codes with the appropriate concern for indoor air quality. ASHRAE will expand its interaction with other professional societies having a common interest in indoor air quality.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.

POSITION STATEMENT ON INDOOR AIR QUALITY

Approved by the Board of Directors July 1, 1987

Introduction

The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) is concerned with the technical means for the conditioning of the indoor environment and with the definition and creation of economically optimum conditions within that environment while minimizing adverse effects on the outdoor environment.

To this end, the Society sponsors research and develops standards and guidelines in a wide range of areas, including that of the practical ventilation levels in indoor environments required to maintain the indoor air quality at acceptable levels.

For these purposes, acceptable air quality is defined as air in which there are no contaminants at harmful or obnoxious concentrations. ASHRAE believes that the indoor air quality should ideally be maintained at levels known to protect even the most sensitive members of the public from both short-term and long-term adverse health effects and discomfort. Practically, however, this does not imply that unreasonably low contaminant levels be maintained in every situation without regard to occupants, sources, and use of indoor environments; it is recognized that there is a diversity of uses for indoor environments.

While progress has been made in improving the quality of outdoor air, indoor environments, in which we spend 90 to 95 percent of our time, have been neglected by comparison. Current trends which lead to reduced ventilation and which introduce new materials into occupied spaces are tending to increase the levels of contaminants in the indoor environment.

Scope and Purpose

This position statement applies to all indoor environments which people may occupy except those which are exclusively industrial environments. Environments of concern include housing and public spaces such as schools, mercantile establishments, offices, transportation (airplanes, automobiles, etc.), and vehicular terminals. The scope does *not* include the acoustical, illumination, vibrational, and thermal aspects of these environments. Also excluded are the effects of air contaminants upon the structure of its non-human contents, such as damage from dust, fungus, etc.

This position statement will define ASHRAE's responsibility with respect to indoor air quality and will express a consensus on the importance of maintaining and improving the indoor air quality. It will make general recommendations for the solution of identified problems through professional practices, regulations or guidelines and will recommend a coordinated research and development program.

Energy Requirements for Ventilation

Buildings consume more than one-third of the total energy used in the United States; ventilation is a major component of building energy demand. In residences, approximately one-third of the energy is used to heat and cool tne one-third to one-half ton of air per hour that typically enters a home from outdoors due to infiltration. Large commercial buildings typically rely on mechanical ventilation rather than infiltration; nonetheless, the fraction of energy used in these structures to heat, cool, and move ventilation air also approaches one-third. Thus, more than one-tenth of the total U.S. energy consumption is now used to ventilate buildings.

Trends in Ventilation and Materials Use Indoors

A conventional response to increases in energy costs is the reduction of infiltration and mechanical ventilation. Many new residences are being designed and constructed with very low air infiltration. In new commercial structures, reduction of design ventilation rates and new ventilation control strategies often reduce ventilation rates from those in past use.

The reduction of ventilation and infiltration may impose a burden on the occupants of a building. Many sources of indoor air contamination exist within buildings. The dominant mechanism for removing many pollutants has been to provide an adequate supply of ventilation air from outdoors. Reducing ventilation usually increases pollutant concentrations if contaminant emissions from inside sources remain constant.

A catalog of pollutant sources within

buildings contains an extensive list. New developments in building technology and in maintenance and cleaning practices are adding to this list. In addition, unvented combustion processes are a major source of many contaminants. Our knowledge of the physiological effects of contaminants is also increasing and may lead to revisions of previously accepted ventilation practices. Therefore, we are confronted with a need for additional pollutant removal precisely at the time when economic considerations dictate a reduction in ventilation rates.

Indoor Air Quality Problems

The effects of chemical and biological contaminants in the indoor air on occupants are complex and, in many cases, inadequately understood. The manifestations of these effects may range from the most obvious, such as eye irritation or odor-related nausea, to various disease states. Some of these effects occur very soon after the beginning of the exposure, while others become apparent only after delays ranging from days for some infectious diseases to many years for substances that act as chronic poisons or carcinogens. These manifestations may be reversible, disappearing without long-range health effects when the offending agent is removed from the indoor air, or may become irreversible health problems needing medical intervention, sometimes without much chance of success.

The chemical and biological effects are further complicated because the same contaminant may have a different effect at different concentrations or with different durations of exposure. As an example, consider a substance that causes both odor and eye irritation. The odor appears at a low concentration, while the irritation typically occurs only at a higher concentration. In addition, a prolonged exposure to the odorant weakens the odor sensation, while a prolonged exposure to the irritant tends to aggravate the irritation.

Some of the problems associated with chemical and biological indoor air contaminants, which have become of increased concern in recent years, are listed below. Sources of the harmful materials may be outdoor air, building materials, furnishing materials, or may result from indoor activities and maintenance practices.

Biological Aerosols. Biological aerosols include aero-allergens and aero-pathogens. Aero-pathogens include bacteria and viruses. Aero-allergens are plant or animal materials which are capable of sensitizing some individuals and thereafter, producing in them inflammatory reactions in the respiratory tract, eyes, or skin. Pollens, which produce hay fever, are rarely of indoor origin and because of their relatively large size are readily excluded from the indoor atmosphere by ordinary filters. Spores, mainly from molds, may originate indoors or out. In addition, house dust contains many small fragments of plants, animal dander, insect parts and fecal matter which can produce allergic reactions.

Indoor air also contains many aero-pathogens which are of human, rather than environmental origin. Some of these may live for some hours in air and infect other people by this route. This is true for the micro-organisms which cause tuberculosis, influenza, etc. Low ventilation rates have been associated with increased infections in both natural and laboratory situations, but quantitative data are almost completely lacking.

Formaldehyde. This is an irritant as well as an odorant. Recently some studies indicate that it is also a carcinogen in animals. It occurs at low concentrations outdoors. Its concentration in indoor air is increased when some formaldehyde-based synthetic resins are used in building materials such as particle board and insulation. Some formaldehyde is produced during incomplete combustion.

Radon. Radon is a radioactive gas produced by the radioactive decay of radium, a radioactive element widely distributed in the earth's crust. Radon in turn decays to form other radioactive elements called radon daughters. Breathing air containing radon daughters increases the risk of lung cancer. The presence of radon and radon daughters does not cause direct sensory warning symptoms, but can be detected and measured by appropriate instrumentation. Radon is present in rocks and soils, ground water, natural gas and in earth-based building materials such as concrete. Actual radon and radon daughter levels that exist in homes and public buildings have been measured in only a limited number of cases; thus, the extent of the exposure of the population to this health hazard is largely unknown.

Asbestos Fibres. Inhaled airborne asbestos fibres cause mesothelioma and lung cancer but only after many years of latency. Asbestos fibres, unless in a very high concentration in air, do not produce any immediately noticeable symptoms. The presence of asbestos is detectable only with specialized equipment. Asbestos and asbestos fibres have been extensively used in building materials in the past but are generally prohibited now.

Carbon Monoxide. This pollutant is an odorless gas which combines with hemoglobin in blood and interferes with the supply of oxygen to body tissues. Its only sensory effect is some lightheadedness which precedes more severe symptoms, including death. It is produced in any process of incomplete combustion of carbon-containing materials. Typical sources are engine exhaust, which may find their way into indoor spaces, tobacco, gas stoves, and unvented or improperly functioning heating equipment.

Sulfur Dioxide. This is an irritant with some odor and with a potential of aggravating respiratory problems. It occurs outdoors as a result of combustion of sulfur-containing fuels. It may be generated indoors if sulfur bearing fuels are burned in unvented or poorly vented heaters.

Nitrogen Dioxide. Nitrogen dioxide is principally a respiratory irritant, and it may interfere with the body's defense against respiratory infections. It is a product of any high-temperature combustion. Sources in the indoor air include unvented combustion processes such as gas ranges and various types of unvented space heaters and tobacco smoking.

Ozone. Ozone is an odorant and an irritant which can cause acute respiratory distress. Ozone is a strong chemical oxidant produced by oxidation of atmospheric oxygen to O_3 under the influence of ultraviolet radiation, other ionizing radiations, or electric discharges. It is always present in outside air and may be generated indoors as well.

Various Other Chemicals. The present chemical technology has introduced, and continues to introduce, a large and growing variety of chemicals into products in wide use in building construction, furnishing, operation, and maintenance. Only a limited number of such chemicals have so far been implicated in health problems, with the present research emphasis being primarily directed towards those which may have carcinogenic or mutagenic properties.

Tobacco Smoke. Tobacco smoke consists of fine particulate matter and complex mixtures of chemical vapors. The harmful health effects of smoke inhaled by the smokers themselves are well documented. The offensive short-range effects of tobacco smoke on the indoor air quality are also well documented in early surveys sponsored by ASHRAE which pointed to tobacco smoke odor as the principal odor problem to be handled by ventilation technology. Hypersensitivity to tobacco smoke is fairly common, sometimes resulting in sever irritation on the eyes and respiratory tracts of people. Studies on young children in households where parents smoke, as compared to children in households without smokers, indicate more frequent respiratory illness in the smoke-exposed children. This passive smoking may be found to cause long-term health effects.

Other Odors of Indoor Origin. There are numerous sources of odor related to the everyday activities of occupants. Odorants emitted by people, food and its preparation, and household chemicals, cosmetics, etc., are an integral part of indoor living. They are generally accepted as such, as long as their sensory intensity is within bounds, and provided that the occupants have some means of reducing the concentration of the odorants by adjusting ventilation (auxiliary exhausts in kitchens, bathrooms; opening doors or windows; or turning on some odorant removal device, such as a vapor filter).

Occasionally, indoor odor sources may be in the ventilation system itself. Under certain conditions of humidity and temperature, colonies of micro-organisms can develop in filters, on cooling coils, or in air ducts. Thus, especially with inadequately maintained air-conditioning systems, the ventilation air may contain more contaminants than the pre-existing indoor air.

Odor Modifiers. One form of control of unpleasant odors involves the addition of chemical vapors to the air. The ability of some chemicals to interfere with the perception of certain odors is reasonably well documented. As a rule, this effect occurs only near the threshold level of the odor perception. The pre-existing odor character is modified, making it less characteristic and less attention-attracting. Sometimes the perceived overall odor intensity appears to be modestly reduced. There is no solid evidence that odor modifiers destroy, chemically change, neutralize, or remove odorants already present in the air.

General Comments on Indoor Air Contaminants. Among the various contaminants mentioned above, those generated principally indoors and affecting occupants either as toxic, carcinogenic, mutagenic, or irritating agents deserve particular attention. Radon, asbestos fibres, unvented combustion products, formaldehyde, tobacco smoke, and chlorinated organic chemicals are prominent examples.

General Principles of Control of Indoor Contaminants

These are three principal methods for control of indoor air quality:

1. removal or control of the contaminants at the source
2. removal or control of the contaminants from the indoor air by processing the air
3. dilution by less contaminated air, with or without energy recovery.

Although the general approaches alone, or in combination, will be effective in obtaining any desired indoor air quality, the specific choices for any particular problem are exceedingly complicated. There are broad issues of public perception, acceptance, enforcement, and resource allocation. As an example, until ten years ago the option of dilution by ventilation was widely preferred. Since then, the increase in energy costs has made this option less attractive.

The best choice for any given space will depend on specific characteristics of the space, including occupant, sensitivity, building characteristics, use of the space, costs, required effectiveness, and many practical considerations of installation, operation, and maintenance. If research can identify the optimal strategies for specific cases, then we predict that the aggregate energy savings and increased public health value will be large compared to the public investment required to carry out this research. The greatest research needs are in the areas of the adverse health effects, the characterization of sources, air change rates (ventilation and infiltration) of buildings, and the further development of practical filtration methods so that the most effective control options can be identified and applied. Simple solutions requiring additional ventilation air without regard to the effect on the system can be counterproductive.

Recommendations

ASHRAE believes that private interests alone cannot perform the research to identify problems and develop the generic means for the solutions. It is in the public interest to quantify the health risks associated with air contaminant exposures encountered indoors. Cost-effective and efficient means of reducing the health risks must be identified. Public policy options for maintaining and improving the air quality of indoor spaces must be developed. Once the research has identified needs for better solutions for improved health, ASHRAE believes the private sector will respond to the needs with improved, innovative, cost-effective solutions.

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Bibliography

Because the interest in indoor air pollution has increased rapidly in the last several years, the recent scientific literature on indoor air pollution is mainly concentrated in four major publications appearing below. The fifth publication summarizes the economic importance of energy use in the buildings sector and the energy conservation opportunities in buildings.

"Health Aspects Related to Indoor Air Quality," Report on a WHO Working Group, Euro Reports and Studies No. 21, Regional Office for Europe, World Health Organization, Copenhagen, 1979.

"Indoor Pollutants," Committee on Indoor Pollutants, Board on Toxicology and Environmental Health Hazards, National Research Council, National Academy Press, Washington, D.C., 1981.

"Symposium on Health Aspects of Indoor Air Pollution," Bulletin of the New York Academy of Medicine, Vol. 57 (10): 825-1084, New York, N.Y., December 1981.

"Indoor Air Pollution: Proceedings of the International Symposium on Indoor Air Pollution, Health and Energy Conservation," Environment International, Pergamon Press, Elmsford, N.Y., 1981.

"A New Prosperity—Building a Sustainable Energy Future," the SERI Solar/Conservation Study, Brick House Publishing, Andover, Mass., 1981.

Current ASHRAE Publications Resulting from Cooperative Research with Federal Agencies (excluding standards)

* Passive Solar Heating Analysis Design Manual
* Survey of Thermal Energy Storage Installations in the U.S. and Canada
* Proceedings of the Conference on Management of Atmospheres in Tightly Enclosed Spaces
* Applications of Solar Energy for Heating and Cooling of Buildings
* Bibliography on Available Computer Programs in the General Area of Heating, Refrigerating, Air Conditioning and Ventilating
* Manual of Acceptable Practices for ASHRAE Standard 90 "Energy Conservation in New Building Design"
* Cooling and Heating Load Calculation Manual
* Design of Smoke Control Systems for Buildings
* Handbook of Experiences in the Design and Installation of Solar Heating and Cooling Systems
* Direct Application of Geothermal Energy
* Proceedings of the ASHRAE/DOE Conference on the Thermal Performance of the Exterior Envelopes of Buildings I (Orlando)
* Proceedings of the ASHRAE/DOE Conference on the Thermal Performance of the Exterior Envelopes of Buildings II (Las Vegas)
* Solar Collector Performance Manual
* Proceedings of the Workshop on Solar Energy Subsystems for the Heating and Cooling of Buildings
* Solar Domestic and Service Hot Water Manual

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
PROGRAM OVERVIEW

SOLAR ENERGY

Solar Energy technologies play an integral part in the current National Energy Policy Plan. The DOE Solar Energy research and development program is designed to help promote a balanced national energy supply mix, maintain environmental quality, and minimize Government interference in the marketplace.

Solar Energy consists of several different conversion technologies which are capable of meeting various end uses. Solar building technologies focus on the heating, cooling and lighting of structures. Photovoltaics and Wind energy systems represent both central and distributed electric generation options. Solar Thermal technology can generate electricity and also provide high temperature heat for industrial applications. Biofuel technologies are capable of producing energy in both liquid and gaseous forms. And finally, ocean systems offer a source of energy for generating electricity and fueling energy intensive industrial processes.

The FY 1986 budget is based on results from an extensive Renewable Energy multiyear program strategy review. Quantitative analyses of potential technology energy contributions in different possible market segments were conducted. An evaluation was also performed to assess probable research effectiveness, and the appropriate Federal role. Individual energy technologies were ranked, and key subprogram activities which appear to suggest relatively high potential have been identified for funding consideration.

Solar technologies offer many energy application advantages. They are versatile in terms of system size modularity, end use flexibility, and relatively minimal operating requirements. Planned research activities will concentrate on a more complete characterization of individual solar technologies, in addition to improving the efficiency and reliability of materials and energy conversion processes.

In conjunction with the Department's sponsorship of research, the need for technology transfer activity is also recognized. Some such activities are funded directly within the programs, but in most advanced technology areas, industry participation and cost-sharing are expected to be the most effective technology transfer mechanisms.

In conclusion, this FY 1986 budget reflects a sound commitment of Federal resources to continuing the evolution of solar energy technologies. The proposal will increase the understanding of solar energy potential, and contribute information required for further non-Federal development and application.

Also note that annual revision to the comprehensive program and plan for Federal energy education, extension, and information activities required by section of the National Energy Extension Service Act, 42 U.S.C. §707, is being submitted contemporaneously to Congress as a separate document with the submission of this budget.

FY 1984 and Anticipated FY 1985 Accomplishments

Solar Buildings Energy Systems

o Completed testing of polymer/foil collector prototypes at various sites to obtain thermal and operating performance data for validating laboratory and analytical performance predictions.

o Completed testing of advanced evacuated-tube, compound parabolic concentrator collectors on an all-day basis through various weather cycles to assess performance of these prototype high temperature collectors, and evaluate tube-to-tube interconnection techniques.

o Constructed a Solar Energy Research Institute (SERI) desiccant heat transfer research lab for the desiccant cooling program, and will subsequently complete simulation tests for verifying analytical models of components/system operation and performance.

o Completed laboratory testing of double-effect regenerative absorption-cycle, solar driven chiller prototype in the cooling mode, and commenced tests in the heating mode.

o Completed the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Passive Solar Heating Analysis Handbook.

o System experiments and analyses have confirmed that roof apertures of very modest areas are adequate to satisfy an appreciable fraction of single story/low rise office building lighting requirements, with corresponding reductions in cooling loads.

o The twenty-one sites of the Nonresidential Experimental Buildings Program represent the first organized broad scale effort to monitor and evaluate the role of passive solar technologies in meeting the heating, cooling, and lighting requirements of such structures. A most thorough collection of passive solar performance evaluation data and design documentation was provided to private industry for use in designing single story/low rise nonresidential buildings.

o Produced durable low-emittance, high-transmittance gradient index titanuim nitride films to reduce thermal losses through windows, particularly in retrofit of existing buildings.

o Developed the first practical samples of transparent insulating window materials using microporous silica aerogel materials.

o Developed a liquid convection thermal diode that can efficiently transport thermal energy by non-mechanical means from building exterior surfaces to the interior, thus verifying the feasibility of this new concept.

o Synthesized phase change materials and incorporated them in conventional building materials, resulting in a tripling of their heat capacities.

o Confirmed, using tests and analyses, the feasibility of projecting daylight up to forty feet into a building's interior by use of holographic or angular-selective films and light projecting assemblies.

o Initial optical switching material experiments have been completed, demonstrating a 60% increase in the reflectivity from electrochromic films. This will accelerate the application of such innovative techniques to the control of solar gain in buildings.

o Synthesized thermochromic coatings, which when applied to apertures or opaque building walls, can either reflect solar radiation in summer or absorb solar energy in the winter.

o Information on the performance of first generation passive heating systems in single-family residential buildings was prepared by the National Association of Home Builders, and made available to representatives of other building industry trade/professional groups for distribution to their members.

Photovoltaic Energy Systems

o Attained a 12½ percent efficient polycrystalline thin film cell.

o Produced amorphous silicon submodules with areas of 250 square centimeters and 6 percent efficiency.

o Produced gallium phosphorous on a silicon epitaxial structure.

o Completed fluidized bed reactor development for producing semiconductor grade silicon from silane.

o Produced web ribbon samples with minority carrier diffusion lengths greater than 100 microns.

o Produced 21 percent single crystal silicon cells.

o Obtained preliminary identification of key failure mechanisms in thin film modules.

o Produced and tested gallium arsenide modules.

o Concluded technology transfer on intermediate and central utility sized photovoltaic applications.

o Completed all balance-of-system research except power conditioning.

Solar Thermal Energy Systems

o Completed preliminary technical and economic assessments of a base-line Direct Absorbing Receiver and Thermal Storage (DARTS) System.

o Initiated testing of a 3-meter focused stretched membrane module to establish membrane/frame coupling.

o Completed Molten Solar Electric Experiment (MSEE) checkout, and concluded the subsequent Phase II test and operation.

o Completed solid particle receiver radiant heat test.

o Completed Vanguard I Stirling engine module performance evaluation and life testing.

o Awarded contracts for innovative advanced dish concentrator designs, and initiated the preliminary design phase.

o Completed the Barstow, CA. 10 MWe Pilot Plant test and evaluation phase, and finished the first year of a three-year power production period.

o Issued a solicitation, awarded contracts, started design and site preparation for construction of Small Community Solar Experiments in Osage City, KS and Molokai, HI.

o Completed qualification testing of five modular industrial solar retrofit (MISR) systems.

o Completed the Shenandoah Total Energy System Project test and operation phase, and transferred facility ownership to Georgia Power.

o Completed the Industrial Process Heat (IPH) Program with the transfer of all sponsored projects to the private sector.

o Initiated a repowering subsystem and component project (category B)

o Completed repowering final design activity for a proposed sodium central receiver at Carrisa Plains, CA.

Biofuels Energy Systems

o Evaluated the potential of intensive management and interplanting of natural stands for increased biomass production in the Great Lake States.

o Explored biosynthetic pathways of hydrocarbon production in herbaceous plants to determine whether methods for increasing hydrocarbon production are feasible.

o Identified and characterized ten promising candidate microalgae species for further research and evaluation.

o Initiated technical and economic analysis of microalgae as an energy source.

o Initiated concentrated hydrogen sulfate acid hydrolysis experiments to determine mass balance.

o Initiated evaluation of ethanol and methanol R&D in light of estimated energy supply and world markets.

o Completed the anaerobic upflow bioreactor (Anflow) project which utilizes fixed films of bacteria in a packed-bed column to purify sewage waste water and produce methane gas.

o Identified range of heat transfer coefficients in an indirectly heated gasifier utilizing a metal fire-tube heat exchanger. The fire-tube concept offers a potentially effective approach to biomass gasification heating without oxygen which is applicable to both medium-btu fuel gas and synthesis gas.

o Quantified the effect of methane/wood mass ratio on the synthesis of fuels in fast pyrolysis.

o Defined temperature range for optimum oil/gas yield and developed a model for ablative fast pyrolysis.

o Completed assembly of a bench scale pyrolysis reactor, and recorded data on off-gases and condensed liquids produced from pyrolysis of selected Municipal Solid Waste components.

o Identified superior genotypes and clones of at least 2 short-rotation woody species.

o Provided a preliminary evaluation of herbaceous species suitable for growth on marginal sites in the Southeast and Midwest/Great Lake Regions.

o Determined properties and composition of oils and lipids for salt-tolerant microalgae.

o Began laboratory testing of enzymatic hydrolysis to verify parametric analysis.

o Improved high solids concentration (75%) of Municipal Solid Waste in anaerobic digestion processes.

o Continued development of a system for the recovery of short chain organic acids from anaerobic digestion processes.

o Conducted base matrix of experiments in process research unit gasifiers.

o Conducted cold flow model testing to evaluate large-scale problems in thermochemical conversion.

o Conducted characterization of selected high-moisture feedstocks for thermochemical conversion.

o Conducted full-scale combustion tests in an operating test facility in order to enhance Municipal Solid Waste combustion efficiency and reduce emissions.

Wind Energy Systems

o Developed an initial model of wind turbulence and velocity variability experienced by rotating turbine blades.

o Performed industry-funded tests, in addition to supporting Department of Defense and state programs at the Wind Energy Research Center in Rocky Flats, CO.

o Conducted meetings with industry to identify research and development needs for the Federal Wind Energy Program.

o Continued detailed design and initiated long lead-time procurement for the Mod-5B (Boeing) advanced wind turbine and project documentation, in addition to orderly closing out the General Electric Mod-5A contract.

o Continued large scale turbine research testing of a full three machine (Mod-2) cluster at Goldendale, WA, following repairs of low speed drive shafts.

o Validated unsteady airflow theories by blade pressure testing on vertical and horizontal axis systems.

o Initiated construction of improved vertical axis system test bed for research testing of intermediate-scale machine concepts.

o Initiated major cooperative research program with windfarm developers and wind turbine manufacturers.

o Consolidated Rocky Flats and Solar Energy Research Institute (SERI) wind energy programs into a single research center.

Ocean Energy Systems

o Completed the cost-shared preliminary design of a 40 MWe Ocean Thermal Energy Conversion (OTEC) power plant for Oahu, HI.

o Reduced the projected capital cost of closed cycle OTEC heat exchangers from $2,200/KWe to $1,100/KWe by qualifying a first generation mass-producible aluminum design as a substitute for the baseline, labor intensive, titanium shell and tube configuration.

o Developed a method for comparing OTEC open and closed cycle performance and life cycle cost which can also be used in prioritizing program research activities.

o Completed deployment and installation of a low cost fiberglass 2.4 meter (8 foot) diameter instrumented cold water intake pipe on a steep underwater slope, and experimentally verified a numerical model developed to predict loads for slope mounted OTEC components.

o Developed an analytical model which experimentally verified countercurrent and co-current flow open cycle condensers.

o Completed fabrication and installation of experimental apparatus for determinating open cycle heat and sea water mass transfer properties.

o Completed modification and testing of a pneumatic wave energy conversion machine.

o Completed a generic environmental assessment for the Hawaii Sea Coast Test Facility.

o Established boundary limits for the use of latent heat mechanisms to reduce OTEC cold water pipe requirements, cost, and risk.

Solar Technology Transfer

o Coordinated arrangements for referral of public inquiries to energy information and assistance services; including specific notices regarding the scope of responses provided by the DOE Conservation and Renewable Inquiry and Referral Service (CAREIRS), the Solar Energy Research Institute and its Technical Inquiry Service, the National Appropriate Technology Assistance Service, DOE's Technical Information Center, and the Energy Information Administration (EIA) National Energy Information Center.

o Developed a unified solar energy exhibit for showing at trade shows and energy expositions. The first display of this unit was at the 1984 Renewable Energy Technologies Symposium and International Expositions (RETSIE) in Anaheim, CA.

o Publicly demonstrated the Conservation and Renewable Energy Inquiry & Referral Service (CAREIRS) computer-base inquiry system at RETSIE-84.

o Coordinated the private publication of two books from the Solar Technical Information Program.

o Anticipate responding to at least 80,000 public inquiries in FY 1985 regarding the application of energy conservation and renewable energy technologies, an increase of 60% over FY 1984 activity.

o Plan to hold 8 to 10 seminars and workshops to disseminate R&D results representing significant technical advances for cost-effective applications.

o Shall complete the first volume in a series of comprehensive reports on solar energy buildings applications R&D findings.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
SOLAR ENERGY
ENERGY SUPPLY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narravtive material in whole dollars)

	FY 1984 Appropriation	FY 1985 Appropriation	FY 1986 Base	FY 1986 Request
Solar Energy (CE)				
Solar Buildings Energy Systems				
Operating Expenses..........	$ 16,363	$ 9,540	$ 9,540	$ 9,000
Capital Equipment...........	0	200	200	500
Subtotal..................	16,363	9,740	9,740	9,500
Photovolatic Energy Systems				
Operating Expenses..........	48,682	46,105	46,105	43,600
Capital Equipment...........	0	1,000	1,000	1,200
Construction................	1,500	9,500	9,500	0
Subtotal..................	50,182	56,605	56,605	44,800
Solar Thermal Energy Systems				
Operating Expenses..........	43,431	34,720	34,720	28,100
Capital Equipment...........	250	500	500	300
Subtotal..................	43,681	35,220	35,220	28,400
Biofuels Energy Systems				
Operating Expenses..........	28,250	29,820	29,820	27,800
Capital Equipment...........	0	1,000	1,000	600
Subtotal..................	28,250	30,820	30,820	28,400
Wind Energy Systems				
Operating Expenses..........	26,367	28,680	28,680	20,000
Capital Equipment...........	0	200	200	800
Subtotal..................	26,367	28,880	28,880	20,800
Ocean Energy Systems				
Operating Expenses..........	5,465	4,480	4,480	3,500
Subtotal..................	5,465	4,480	4,480	3,500
International Solar Program				
Operating Expenses..........	500	500	500	0
Subtotal..................	500	500	500	0
Solar Technology Transfer				
Operating Expenses..........	3,250	6,000	6,000	3,100
Subtotal..................	3,250	6,000	6,000	3,100
Solar Energy Research Institute				
Capital Equipment...........	0	0	0	261
Construction................	0	0	0	2,071
Subtotal..................	0	0	0	2,332
Program Support				
Operating Expenses..........	773	1,000	1,000	1,300
Subtotal..................	773	1,000	1,000	1,300
Resource Assessment				
Operating Expenses..........	0	0	0	950
Capital Equipment...........	0	0	0	50
Subtotal..................	0	0	0	1,000

	FY 1984 Appropriation	FY 1985 Appropriation	FY 1986 Base	FY 1986 Request
Program Direction				
Operating Expenses..........	6,000	4,766	4,766	4,900
Subtotal..................	6,000	4,766	4,766	4,900
Total				
Operating Expenses...........	179,081	165,611	165,611	142,250
Capital Equipment............	250	2,900	2,900	3,711
Construction.................	1,500	9,500	9,500	2,071
Solar Energy	$180,831 a/	$178,011 b/ c/	$178.011	$148,032 c/
Staffing				
Total FTE	89	87	87	88

a/ The FY 1984 appropriation was reduced by $819,000 reprogramming for Small Business Innovative Research (SBIR).

b/ Reflects savings of $883,000 for Section 2901 of the 1984 Deficit Reduction Act (P.L. 98-369).

c/ Amounts do not reflect the reduction of $6,099,000 in FY 1985, and $3,300,000 in FY 1986, for Inspector General audits/prior year deobligation Management Initiative Savings.

Authorization:

- P.L. 93-473, Solar Energy Research, Development and Demonstration Act
- P.L. 93-577, Non-Nuclear Energy Research and Development and Demonstration Act
- P.L. 95-390, Solar Photovoltaics Energy Research, Development and Demonstration Act.
- P.L. 95-911, Department of Energy Organization Act
- P.L. 96-294, Energy Security Act
- P.L. 96-310, Ocean Thermal Conversion Research, Development and Demonstration Act
- P.L. 96-345, Wind Energy Systems Act
- P.L. 98-370, Renewable Energy Industry Act

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(In thousands of dollars)

SOLAR ENERGY

FY 1985 Conference Mark	$ 179,399
Less: ADP Reduction	-505
Proposed Rescission	-883
FY 1985 Adjusted	178,011
Built in increases and decreases:	0
FY 1986 base	178,011
Program increases and decreases:	
Solar Building Energy Systems	
o Materials and components	-475
o Systems research & development	-65
o Supporting capital equipment	+300
Subtotal, Solar Buildings Energy Systems	-240
Photovoltaics Energy Systems	
o Materials research	-1,045
o Systems research	-3,550
o Sacramento Municipal Utility District Power Station (terminiates DOE funding participation)	-9,500
o Supporting capital equipment	+200
Subtotal, Photovoltaic Energy Sustems	-11,805
Solar Thermal Energy Systems	
o Collection technology	+466
o Energy conversion	-936
o Systems technology	-5,640
o Planning & assessment	-510
o Supporting capital equipment	-200
Subtotal, Solar Thermal Energy Systems	-6,820
Biofuel Energy Systems	
o Short rotation intensive culture	+500
o Feedstock production research	-2,370
o Thermochemical conversion technology	-1,750
o Biochemical conversion technology	+3,600
o Regional biomass programs	-2,000
o Supporting capital equipment	-400
Subtotal, Biofuel Energy Systems	-2,420
Wind Energy Systems	
o Aerodynamic research	+1,420

o Structural dynamics research.........................	+1,600
o System analysis and evaluation.......................	-200
o Small wind test center-operation & maintenance........	+200
o Mod-5 multi-megawatt turbine development (final DOE funding).......................................	-11,700
o Supporting capital equipment.........................	+600
Subtotal, Wind Energy Systems......................	-8,080
Ocean Energy Systems	
o Materials and structures.............................	+20
o Thermodynamics research..............................	-83
o Experimental verification and testing................	-467
o Environmental/oceanographic research.................	-150
o Wave energy..	-300
Subtotal, Ocean energy systems.....................	-980
International Solar Energy Programs	
o International trade development (terminate)..	-500
Solar Technology Transfer	
o Technical and general information compilation, and dissemination..	-2,900
Solar Energy Research Institute (SERI)	
o General purpose capital equipment....................	+261
o General plant improvement projects...................	+2,071
Subtotal, Solar Energy Research Institute..........	+2,332
Program Support	
o Generic program planning & analysis, telecommunication/ automated office expenses...........................	+300
Resource Assessment	
o Measurement, modeling, algorithm and methodology development..	+1,000
Program Direction	
o One additional FTE (total 88 FTE), repricing and 5% pay reduction................................	+134
FY 1986 budget request................................	$ 148,032

Solar Buildings Energy Systems $ 9,500,000

The FY 1986 President's Request for Solar Buildings is $9,500,000, a decrease of $240,000 from the FY 1985 appropriation.

Materials and Components Research $4,900,000

Research has shown that solar heating, cooling, and lighting systems can be technically feasible in a large variety of hot water, space heating, cooling, and daylighting applications. However, performance-to-cost ratios must be significantly improved. In particular, materials and major components must achieve dramatic cost reductions and performance improvements. This requires development of materials with improved thermal, chemical, optical, and structural properties; lower cost materials with improved durability; and, more efficient components and methods for collection, conversion, storage and distribution of solar energy.

The specific FY 1986 activities that will be conducted are:

- Thin-film polymer/foil flatplate collectors in the medium temperature range (140°F-120°F). Research is needed to develop new, less expensive collector designs using thin-film polymer/foil components or other low-cost materials which suffer no significant loss in performance and durability. Research to be performed includes: photothermal stabilization of films via surface treatment, bulk additives, copolymerization and multi-layer construction which can extend lifetimes to 10 years or more; development of absorber foil and film combinations, and lamination processes thermally stable up to 200°F with good heat transfer characteristics; and design, fabrication testing and analysis of prototype designs using these low cost materials to resolve problems associated with thermal cycling, collector stagnation or freezing. ($1,300,000)

- Desiccant materials and components. Evaluation of small prototypes in dehumidification and regeneration tests have predicted a coefficient of performance (COP) of 1.5. Funds are requested to determine physical and chemical properties, cycle lifetime, and degradation of liquid and solid desiccants on prototype dehumidifiers to achieve a COP of 1.5 in laboratory units. ($650,000)

- Evacuated-tube, compound parabolic concentrator (CPC) collectors. New high temperature (210°F-300°F) collector components and materials which can perform special functions are needed for use in advanced absorption cooling system concepts. The Department proposes to develop, test, and analyze new materials and design configurations for higher temperature evacuated tube CPC collectors that can generate steam or other vapors for cooling and/or industrial process heat applications. Funds are requested to fabricate and test high-performance collector prototypes for incorporation into absorption/Rankine cycle heating and cooling systems. Materials research will focus on the problem of maintaining high-temperature stability of selective absorption surfaces on the receiver tube in order to maintain absorptivity and emissivity values while surviving repeated exposure to stagnation temperatures of 300-750°F. R&D to develop and test collector prototypes with efficiencies of 60% at 350°F will be conducted with the objective of achieving a useful life of 20 years, and the potential for low manufacturing costs. ($600,000)

- Chiller materials and components. First generation absorption and Rankine chillers have been built and tested. However, these early prototypes are not economically competitive. Systems which have the potential for increasing the cost-to-performance ratio by a factor of two to four over today's prototypes are needed. Funds are requested to begin analysis of second-generation, solar driven absorption cycle machines. The objective is to develop chillers which have the potential for a significant increase in cost-to-performance efficiencies (COP of 1.5 for cooling; 2.0 for heating), thus enabling a reduction in operating costs.($350,000)

- Aperture materials. Research and analysis will be conducted to accelerate development of new materials for building apertures and surfaces. Such advancements will permit building occupants to either accept or reject solar radiation as required for heating and cooling and to provide enhanced daylighting deep within building interiors so as to reduce consumption of electric lighting. Experimental and analytical studies will be conducted in low-conductance materials and optical switching films to minimize uncontrolled energy losses through building apertures. ($550,000)

- Thermal storage and transport materials. Research is directed toward improvements in materials and components which are capable of storing, within building structural elements, the abundant heat available in the daytime for use at night or other peak demand periods. Scientific experiments with solid/solid thermal storage materials will increase understanding of complex compounds capable of storing sensible and latent heat in stable forms that can be self-encapsulated in building materials, with potential characteristics of switchable controls employed by building occupants. Investigations will focus on thermal performance testing of self-encapsulating thermal storage materials synthesized in FY 1985 which avoid the need for specific containers and enhance the thermal performance of conventional building materials. Compounds to be tested will possess solid/solid phase change materials properties, with operating temperatures for heating purposes in the range of 75°F to 95°F, and heat of fusion of at least 4500 Btu's per cubic foot. For cooling buildings, solid/solid phase change materials will be tested for performance within the operating temperatures of 50°F to 75°F. Research in thermal transport materials and advanced concepts will be directed towards doubling the performance of passive solar heating technologies by employing more efficient means for transporting, with controlled non-mechanical measures, the passive solar-derived energy from the exterior building surface to the interior to improve interior comfort conditions. Research in FY 1986 will include full-scale tests, as a follow up to FY 1985 test room experiments, of convective liquid and liquid/vapor thermal diodes that provide thermal transport in multi-zoned new and existing buildings. Advanced heat pipes, vapor transport loops, and fluidized-bed techniques which concentrate thermal energy from the collection surface, will also be investigated and tested. ($1,450,000)

Systems Research and Development $4,100,000

Solar heating, cooling, and daylighting systems have the ability to effect forty to sixty percent reductions in electric power and fossil fuel requirements for non-residential buildings, and can reduce heating and cooling loads by similar amounts in residential buildings. To realize these goals, basic physical phenomena must be understood; new cooling technologies and emerging materials and components must be integrated into optimal operating systems. Reliable whole building performance data must be available to accurately predict the response of these systems in contemporary buildings before the private sector will implement them.

The specific FY 1986 activities that will be conducted are:

- Research directed at integrated solar building systems which effectively heat, cool, and daylight new and retrofitted non-residential buildings. This research activity includes: (1) Validation of analytical tools that accurately predict the performance of solar heating and cooling systems, and of perimeter and roof monitor daylighting systems, using performance data acquired from appropriate non-residential buildings; design guidelines will be provided to design professionals; (2) Research on deep penetration core daylighting using analytical simulations, scale models, and test cells; (3) Whole buildings performance research that will monitor and evaluate buildings retrofitted with solar building systems; (4) Development of appropriate cooling techniques using thermal mass, phase change materials, and radiative emitters, which are integrated into the building's total energy system; and (5) Systems integration research required to determine optimal combinations of emerging solar materials, components, and systems in different building types within several geographic regions to provide guidance to basic researchers. ($1,900,000)

- Research directed at integrated solar building designs and systems appropriate for heating and cooling new and retrofit multifamily buildings. This research activity addresses a priority need identified by the buildings industry. It focuses upon development of advanced technologies that will meet the energy requirements of structurally complex buildings; since existing technologies are inadequate. Advanced cost-effective solar building technologies can be developed for new multifamily dwellings that are capable of reducing heating fuel use 50-70 percent, and cooling energy use 40 percent. Advanced retrofit systems can be developed for existing multifamily buildings capable of reducing heating fuel use 20-50 percent and cooling energy use 10-20 percent. This research includes: (1) development of heating and cooling systems appropriate for new and retrofit multifamily buildings; (2) experimental studies of multi-zone, one-and two-story convective air flow and its interaction with HVAC systems; (3) determination of the magnitude and distribution of solar radiation and its effect upon heating and cooling loads and thermal comfort; and (4) methodology revisions for performance monitoring of new and retrofit multifamily buildings. ($2,200,000)

Capital Equipment $500,000

The funds will be used for the acquisition of required laboratory support equipment to facilitate planned research activities.

DEPARTMENT OF ENERGY

FY 1986 Congressional Budget Request

KEY ACTIVITY SUMMARY

Solar Buildings
(B/A in $1000s)

KEY ACTIVITY	ESTIMATED ACTIVITIES DURING FY 1985	PLANNED ACTIVITIES FOR FY 1986
Thin-film polymer/foil collectors	Complete design and begin fabrication of medium temperature collector prototypes using thin-film polymer materials and advanced design concepts. ($1,200)	Complete fabrication and begin testing of several medium temperature design concepts; continue research on materials degradation. ($1,300)
Desiccant Materials and Components	Conduct studies of liquid-liquid and liquid-vapor equilibria associated with water as part of an investigation of new materials for incorporation into monolithic slab desiccant beds, and methods to coat macrofibers of other structural materials that will contribute mechanical integrity and thermal conductivity to large bonded aggregates. ($800)	Continue FY 1985 activities plus determine physical and chemical properties, cycle lifetime, and degradation of liquid and solid desiccants. ($650)
Evacuated-tube, compound parabolic concentrator (CPC) collector development	Testing of advanced evacuated tube collector which uses a CPC shaped mirror assembly. Methods for heat removal will be evaluated to determine advantages of pumping a fluid through the absorbers or using heat pipes for the absorber. Manifolding will be designed to allow use of either a conventional liquid heat transfer fluid or a phase-change heat transfer material. ($400)	Continue FY 1985 program. ($600)
Chiller Materials and Components R&D	Laboratory testing of double-effect (2R) chiller in the cooling mode. Complete design and begin fabrication of single-effect regenerative absorption refrigeration cycle chiller. ($800)	Laboratory testing of the double effect (2R) chiller in the heating mode to achieve stable operation. Perform analysis of second-generation solar driven absorption cycle machines plus design of closed-cycle absorption heat pumps capable of 1.5 COP in the cooling mode, and 2.0 in the heating mode. ($350)

DEPARTMENT OF ENERGY

FY 1986 Congressional Budget Request

KEY ACTIVITY SUMMARY

Solar Buildings
(B/A in $1000s)

KEY ACTIVITY	ESTIMATED ACTIVITIES DURING FY 1985	PLANNED ACTIVITIES FOR FY 1986
Aperture Materials	Continue research, analysis, fabrication, and testing of metal oxide coatings, solid-state electrochromics, low-conductance materials, and selective/directional glazings. ($1,080)	Fabricate and test low conductance, high transmittance silica aerogel materials for light scattering, thermal impedance, stability, and durability; test electrochromic materials for solar incident radiation control and reduction of cooling loads. ($550)
Thermal Storage and Transport Materials	Identify high thermal performance phase change materials; synthesize and evaluate new crystalline polymers; identify candidate subsystems for heat pipe and thermal diode research. Initiate investigation of thermal diode and vapor transport subsystems. ($960)	Synthesize salt hydrates for thermal storage in building materials; synthesize and test solid/solid phase change materials for heating and cooling purposes; investigate phase change materials microencapsulated or matrix immobilized in conventional building materials; test fluidized bed concept for thermal transport; initiate investigations of thermal diode control mechanisms. ($1,450)
Experimental Systems Research	Analyses to assess component irreversibilities and to define optimum cycle and component performance for absorption solar heating and cooling systems. Experiment on closed cycle absorption systems-related problems, and improve performance data of open-cycle absorption system prototype using packed-bed regenerator concepts during both heating and cooling modes of operation base. ($1,410)	No FY 1986 funding requested. ($0)

DEPARTMENT OF ENERGY

FY 1986 Congressional Budget Request

KEY ACTIVITY SUMMARY

Solar Buildings
(B/A in $1000s)

KEY ACTIVITY	ESTIMATED ACTIVITIES DURING FY 1985	PLANNED ACTIVITIES FOR FY 1986
Systems Integration Research; Non-Residential Buildings	Characterize and initiate validation of strategies which optimize integrated passive heating, cooling, and daylighting systems in existing non-residential buildings. Continue evaluation of perimeter roof monitor daylighting systems. Initiate analysis and evaluation of primary integrated cooling strategy identified in FY 1984. Provide research results to the buildings industry. ($1,460)	Develop, validate, and evaluate the performance of heating cooling, and daylighting systems which are integrated with conventional space conditioning and lighting systems in single story/low rise non-residential buildings. Complete validation of analytical tools which accurately predict the performance of roof monitor and daylighting systems; continue research on deep penetration core daylighting. Continue development of integrated cooling techniques that use thermal mass, phase change materials, and radiative emitters. Conduct heat transfer experiments to predict and measure dynamic heat transfer and air flows in multichamber full scale enclosures. Use validated analytical/predictive tools to develop whole building design guidelines. ($1,900)
Systems Integration Research - Residential Buildings	Characterize passive heating and cooling system requirements unique to new and existing multifamily residential buildings. Continue validation of predictive algorithms in public domain solar building energy analysis codes using high quality data from test cells and full scale enclosures. Initiate research on multi-zone convective heat transfer and air flows. ($1,430)	Develop, validate, and evaluate strategies which optimize integrated heating and advanced cooling systems in multifamily residential buildings; initiate research to integrate these systems with conventional space conditioning systems; collect high quality heat transfer, air movement, infiltration, radiation, and stratification data to continue validation of predictive analysis codes. Develop a short-term monitoring method for predicting long term performance of occupied residential buildings. ($2,200)

DEPARTMENT OF ENERGY

FY 1986 Congressional Budget Request

KEY ACTIVITY SUMMARY

Solar Buildings
(B/A in $1000s)

KEY ACTIVITY	ESTIMATED ACTIVITIES DURING FY 1985	PLANNED ACTIVITIES FOR FY 1986
Capital Equipment	($200)	Funds for the acquisition of required laboratory support equipment to facilitate planned research activities($500)
Total Solar Buildings	$ 9,740	$9,500

Photovoltaic Energy Systems	$44,800,000

The FY 1986 Budget Request for Photovoltaic Energy Systems is $44,800,000. This represents a $11,805,000 decrease from the FY 1985 appropriation.

The purpose of this program element is to sponsor high-risk, potentially high-payoff research and development in photovoltaic energy technology that will result in a technology base from which private enterprise can choose options for further development and competitive application in U.S. electrical energy markets.

Materials Research	$31,650,000

Advances in materials science and technology are key to the continuing technical and industrial development of high-performance, reliable, low-cost photovoltaic devices and modules. These are needed for cost-competitive penetration into large-scale, commercial, residential, industrial and utility markets. Modules based upon crystalline (single-crystal and polycrystalline wafers and ribbons) silicon cell materials are commercially available and hold the most immediate promise of producing electricity at a cost that can be competitive in U.S. high-cost electricity markets (e.g., remote locations requiring stand-alone electrical power systems and utilities with gas and oil-fired generating plants).

In the longer term, it is projected that research on thin-film photovoltaic cells can result in high-performance, low-cost photovoltaic power systems, which could be competitive with newly-built electric power systems based upon fossil and nuclear fuels. Thin- film cells have two important advantages: low materials requirements and potential for low-cost production technologies based upon continuous fabrication of entire modules. In the materials research element of the program, significant cost sharing (20 to 30 percent and more) is occurring in several sub-elements (e.g., amorphous silicon) in spite of the high-risk. In many areas of the program, contractors are willing to participate with their own funds in order to retain commercial rights to the developments that might arise. Materials research areas are as follows:

-- Amorphous Silicon ($10,100,000): R&D activities will be conducted on issues important to cell performance, stability, fabrication, and longer-term costs of production. The project encompasses material selection and characterization; deposition technology; characterization of films, surfaces and interfaces as a function of deposition parameters and methods; measurement of diffusion lengths, minority carrier lifetimes, alloying characteristics, and surface and bulk recombination rates; modelling and analysis of materials and cell structures; and comparisons with investigations of causes and remedies for light-induced degradation of amorphous silicon cells. It also includes evaluation of materials properties and technical issues that arise in the design and implementation of submodules (e.g., efficiency, interconnection and deposition uniformity). Multiple-junction (stacked) photovoltaic devices offer the possibility of achieving higher efficiencies than single- junction devices. The additional efficiency may more than offset expected additional complexity and cost and thus result in less expensive energy production. Multiple-junction amorphous silicon devices are being investigated using alloying elements including hydrogen, carbon, nitrogen, fluorine, germanium and tin. These devices will be fabricated as monolithic stacks.

-- Single-Junction High-Efficiency Materials ($1,500,000): Although the theoretical conversion efficiencies of silicon cells and (III-V)- based* cells are considerably greater than 25 percent, the highest one-sun efficiencies seen in laboratory cells to date are 19 percent for silicon and 22 percent for gallium arsenide. This activity will support materials, device and modelling research to achieve longer- term one-sun efficiency objectives of 21 to 22 percent and 25 to 27 percent, for silicon and gallium arsenide, respectively.

*Periodic Table Element Groups, i.e., compounds formed by combining one or more elements from Group III with one or more from Group V.

-- (III-V)* Multiple-Junction and High-Efficiency Concepts ($3,800,000): This activity will support research on high-efficiency multiple-junction concepts having the potential to achieve 25 to 35 percent cell conversion efficiencies for economic application in flat-plate and concentrator collectors. Several multiple-junction concepts and a large number of (III-V) and (III-V)-analog semiconductor materials have shown preliminary promise of attaining greater than 30 percent conversion efficiencies. Increased cell and module efficiency is of great value in meeting program economic goals for photovoltaic energy systems relative to competing energy systems based on fossil and nuclear fuels. These high-efficiency cell concepts are largely based upon single-crystal, thin-film materials stacked vertically as grown or as placed in a mechanical configuration. The current state of materials purity, deposition equipment and control, film interface effects and diagnostic techniques, are all substantial scientific challenges to be resolved. Modeling studies and theoretical analysis are required to guide the device research and the optimization of structure and materials to achieve the much-needed increases in advanced collector efficiency.

-- (II-VI)* and Related Materials ($5,400,000): Single-junction polycrystalline thin-film cells have received considerable federal and industrial R&D attention during the past ten years. Conversion efficiencies of a number of thin-film cells have doubled during this time, but have not reached their projected practical potential. Many R&D opportunities need to be explored to obtain higher-performance (e.g., conversion efficiency, stability and lifetime) and lower-cost cells and modules. Advanced thin-film materials showing the most promise include: copper indium diselenide ($CuInSe_2$) and cadmium telluride (CdTe). Improvements of single-junction cells may also be applied to the development of higher-efficiency multiple-junction cells, which are often based upon combinations of the same materials. The program will continue to support research on single-junction thin- film cells to produce improved heterojunction (junction formed between two different materials) and homojunction (junction formed by adjacent layers of the same material with different doping) devices based upon compound semiconductor materials. The major materials of interest over the past five years and continuing into FY 1986 are $CuInSe_2$ and CdTe. Both $CuInSe_2$ and CdTe single-junction cells have reached about 11 percent conversion efficiencies, double that of seven years ago. The longer-term goal of more than 15 percent by 1987 is expected to be met under this project.

-- Advanced Silicon Sheet ($4,500,000): Special emphasis is placed on major theoretical and experimental aspects in the growth of dendritic web single-crystal silicon ribbon. The work encompasses crystal quality, area growth rate and ribbon length. The tasks include stress reduction, melt-convective effects, melt replenishment thermal effects, gas-flow effects and growth-parameter optimization. The goal is to increase dendritic web growth from about 10 cm^2/minute to 30 cm^2/minute, with continuous ribbon growth lengths of at least 50 meters and with crystal quality sufficient to fabricate cells with 17.5 percent average efficiencies. In addition, six other ribbon growth processes are being investigated. Generic thermal and stress models applicable to most ribbon growth processes are being formulated and will be compared with experimental measurements in order to evaluate the validity of a predictive model. Further effort will be directed to the use of the model to predict improved growth-furnace geometries and thermal environments.

-- University and New Ideas Research ($1,500,000): The objective of this program is to support university research and training, promote the development of new ideas, and explore innovative concepts having significant interest and potential impact on photovoltaic science and technology. This thrust is aimed principally at projects and efforts expected to make substantial long-range contributions to the advancement of photovoltaic conversion through coordinated basic and applied research conducted by universities, small

*Periodic Table Element Groups, i.e., compounds formed by combining one or more elements from Group III with one or more from Group V.

businesses and institutes in support of the national program goals. Particular attention will be given to the needs of universities in fulfilling their missions and in creating conditions promoting their maximum contributions to the photovoltaic technology base. Research, new ideas and innovative concepts are expected to include new semiconductor materials, device structures, conversion concepts and characterization methods.

-- Advanced Concepts ($1,500,000): This activity will establish feasibility, including device characteristics, stability, reproducibility and scaleability, of the most promising ideas identified in prior year innovative concepts and Small Business Innovation Research Work.

-- High Efficiency Concepts ($3,350,000): It has now become clear that as a result of FY 1984 and FY 1985 research, several materials will have been developed that, when combined into a multi-junction photovoltaic device, may achieve commercial cell efficiencies of 30 percent under concentration. With the achievement of this important five year plan milestone, photovoltaics will have broken through a barrier to high efficiency. High efficiency offsets the more expensive production, such that cost effective modules can move readily be achieved.

Collector Research $10,500,000

An important part of the DOE photovoltaic energy technology program has been aimed at developing cell and module technology for flat-plate and concentrator collectors. The important concerns in this area are the improvement of module efficiency, reliability and lifetime, while reducing cost. These research tasks are concerned principally with improvement in the performance of materials and components composing a flat-plate or concentrator module; advanced designs to improve module performance, stability and durability; and environmental and outdoor laboratory testing to confirm design expectations and to evaluate long-term operating characteristics.

The program element goal is to establish and transfer technologies to industry capable of producing 15 percent efficient flat-plate modules, and 25 percent efficient concentrator modules. The principal tasks are to avoid or minimize the efficiency losses that occur as cells are combined into modules, to simplify module design, and to understand collector failure mechanisms.

-- Collector Efficiency Research ($6,500,000): The key need in this area is to improve flat-plate and concentrator module efficiencies. This can be accomplished by new fabrication techniques and device improvement ideas.

  Efficiency Improvements: Research will be conducted on technologies that show promise of achieving 15 to 20 percent flat-plate (one-sun) module efficiencies (based upon advanced single-crystal silicon cells, single-crystal gallium arsenide cells and other advanced single-crystal and thin-film cells evolving from the materials research program); and, achieving 25 to 30 percent concentrator (25 to 1000-suns) module efficiencies (based upon advanced single-crystal (III-V) cells, (III-V)-analog cells, and multiple-junction cells evolving from the materials research program).

  Coating and Encapsulant Research: This activity will include research on new coatings to improve cell and module efficiency and reduce cost. Coatings can protect modules from the environment, lower recombination rates on the front surface of solar cells, minimize light reflection by the use of multiple-layer anti-reflection coatings and maximize light transmission to the cells. Special emphasis will be placed upon developing coatings that will perform more than one of the aforementioned functions.

-- Collector Simplification Research ($4,000,000): Although flat-plate collectors constitute the vast majority of private sector photovoltaic sales to date, module design complexity must be further reduced and efficiencies increased for cost-effective use in utility systems. Module simplification can occur through the reduction and even elimination of expensive contacts and conductors used in both crystalline silicon and thin-film devices and modules. This activity will support research to develop improved conductors (metallic or non-metallic) for silicon and other types of cells, and to reduce cell internal power losses due to cell currents passing through semiconductor contacts and conductor resistances. Opportunities will be explored for use of low-cost metallic and/or non-metallic (e.g., conducting polymers) low-resistance conductors for both cell current collection and cell interconnections.

System Research	$1,450,000

Success in establishing a technology base suitable for further development by industry requires verification of the performance of critical components and subsystems. In support of this development, the objectives of systems research are to: (1) verify module performance; (2) verify the integrated performance of modules; and (3) identify improvements in module designs that will result in improving the overall efficiency, life-expectancy, and cost of photovoltaic systems.

This activity supports R&D to establish the technology base for increasing photovoltaic module lifetime and reliability from about 10 years (more than 10 years for flat-plate collectors and less than 5 years for concentrator collectors) to the program goal of 30 years. The 30-year goal for lifetime is of critical importance to the economic competitiveness of commercial photovoltiac systems designed for the domestic utility and the large-scale international markets and to the future of the U.S. photovoltaic industry. Analysis has shown that photovoltaic systems having 30-year life expectancies instead of 10 result in a reduction by about a factor-of-two in the levelized cost of electricity. Efforts under this activity include module failure analysis for both field and laboratory systems; environmental stress testing (under controlled conditions) of commercial crystalline silicon modules and new modules based upon thin-film cells (e.g., amorphous silicon and copper indium diselenide); measurements of the performance characteristics of failing materials; and identification of improved materials and integral module designs to eliminate electrochemical processes, contact resistance, corrosion effects, delamination, discoloring, et. al.

-- Module Failure Mechanisms ($1,450,000): As a result of the operation of a large number (more than 20) of DOE and privately-financed and instrumented photovoltaic systems (many of them approaching 5-years of operation), there is opportunity to examine, classify and/or test failed modules to determine material and design failures. This information will be of great value to industrial module designers and manufacturers and to research groups developing thin-film and concentrator modules.

Capital Equipment	$1,200,000

These funds are needed to procure equipment for the Solar Energy Research Institute (SERI) Laboratory and other contractor laboratories. This equipment is needed to implement (a) new measurement techniques to analyze and evaluate materials and device structures, (b) improved deposition methods for laying down controlled thin-films of materials to formulate new thin-film devices, (c) improved insolation measurements, and (d) improved contacting devices to reduce electrical resistance and improve conversion efficiencies. In particular, these funds will help sustain SERI at the forefront of photovoltaic materials characterization and retain the world-wide reputation it now enjoys.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY

PHOTOVOLTAIC ENERGY SYSTEMS
B/A IN ($1000s)

KEY ACTIVITY	ESTIMATED ACTIVITY DURING FY 1985	PLANNED PROGRAM ACTIVTIES DURING FY 1986
Materials Research	Continue amorphous silicon alloys, (III-V) and (II-V) materials; continue single-junction and multiple-junction device research; continue advanced silicon sheet and innovative concepts; initiate university research program and advanced concepts; complete silicon materials studies ($30,605)	Continue amorphous silicon alloys, (III-V) and (II-VI) materials, and advanced silicon sheet. Continue university research program and advanced concepts. Perform fabrication studies of multijunction cells. ($31,650)
Collector Research	Continue flat-plate and concentrator collector research to increase efficiency and simplify structures ($10,500)	Continue collector research to increase efficiency and simplify structures. ($10,500)
Systems Research	Continue systems technology transfer, module failure mechanisms and institutional issues. ($5,000)	Continue module failure mechanisms studies at a reduced level. ($1,450)
Capital Equipment	Update measurement and obtain advanced research equipment. ($1,000)	Improve the measurement facilities and procure advanced research equipment. ($1,200)
SMUD Construction	Continue Phase III of SMUD Construction. ($9.500)	$-0-
Total Photovoltaics	$56,605	$44,800

Solar Thermal Energy Systems $28,400,000

The FY 1986 President's request for Solar Thermal is $28,400,000, a decrease of $6,820,000 from the FY 1985 appropriation.

Collection Technology Research ($12,900,000)

The objective of this program element is to identify and characterize, collection materials and components suitable for stable long-life performance in concentrating solar applications. Concentrating solar thermal technologies have great potential for cost effective energy production. To better realize this potential, low-cost, light-weight reflectors, high temperature receivers, and concentrators must be developed.

The specific FY 1986 activities that will be conducted are:

- Optical Materials ($2,300,000)

  Research in optical materials includes identification and characterization of reflecting materials, fundamental evaluation of the failure mechanisms of optical surfaces, degradation mechanisms in polymers, high absorptivity coatings, high temperature measurements; and research on refracting optics to determine optical requirements and the appropriate tradeoffs between cost and useful life. Accelerated testing is underway to understand the degradation of polymers from ultraviolet radiation as well as from other envirnomental factors.

  The current research emphasis is on silvered polymers that can reduce the cost of reflective surfaces while maintaining the required performance. This leads to reduced costs of supporting structures by eliminating the higher weight and poor impact resistance of glass mirrors. Other benefits accrue from the improved ease of handling, fabrication and installation. Innovative reflector concepts are also being investigated. The objective is to achieve a breakthrough in concentrator weight and cost.

- Concentrators ($4,800,000)

  Concentrators collect, concentrate and transmit incident sunlight to a receiver where it is converted to thermal energy. Concentrators typically constitute about one-third to one-half the total cost of a solar thermal system. Reducing the weight and cost of concentrators, while maintaining the required level of strength and optical performance, has been a continuing objective of the program. Several approaches are being pursued to achieve the concentrator performance goals. These are; improvement of the current glass mirror concentrators, innovative concentrators, and low cost concentrators utilizing silvered polymers. An example of an innovative concept, which is currently being evaluated, is the stretched membrane concentrator.

  Research, testing and evaluation of low-cost advanced optical concentrators, in cooperation with industry, will be continued and expanded in scope. In FY 1986, work will continue on heliostat design and development for central receiver systems including the construction and testing of prototype membrane heliostats. For parabolic dish concentrator research, testing will proceed on three innovative concentrators initiated in previous years and increasing emphasis on membrane concentrators research.

  Improvements in existing parabolic trough systems have been pursued in cooperating with industry under the Modular Industrial Solar Retrofit (MISR) Program. Significant improvements were made in system reliability and performance; however, this has not been sufficient to ensure penetration of the industrial process heat market. A research effort will continue on an advanced low cost parabolic trough concentrator to meet the energy performance goals.

- Receivers ($5,800,000)

  Receivers are a key feature in all types of solar thermal systems, converting the concentrated sunlight to thermal energy. In parabolic trough systems, the receiver is a long tube located along the focal line of the trough concentrator. A heat transfer fluid, usually a synthetic oil in the higher temperature systems, transmits the heat to the point of use. In parabolic dish systems, a compact receiver is located at the focal surface of the dish and provides the heat input to an engine/generator combination to produce electricity. In the central receiver systems, a field of heliostats (large, nearly flat mirrors) reflects the sunlight onto one centrally located receiver which transfers the absorbed thermal energy to a generator for the production of electricity or for process heat or fuels and chemicals applications.

  In 1986, most of the research effort will be directed toward solving key problems for central receiver systems. Research and development will be conducted in the definition and feasibility of advanced receivers; and research on problems of tube and cavity type receivers with emphasis on cyclic failures, materials and corrosion evaluation, and radiative and convective heat losses. The efforts in advanced receivers will provide the basis for selection of receivers which would operate at higher temperatures and permit systems with increased efficiency.

  A major activity in FY 1986 will be the design and fabrication of a thermochemical receiver for distributed receiver systems suitable for high temperature electric and process heat applications. A number of experiments have shown that solar energy can also be used to produce fuels and chemicals using various feedstocks. The next step is to investigate during FY 1986 the potential receiver and associated system problems that would be encountered in such applications, and to obtain data for deciding whether or not to proceed further in this area.

Energy Conversion Technology Research ($4,500,000)

The objective of this program element is to identify processes and components to convert thermal energy into electricity or other usable energy forms such as fuel and chemicals. It also includes thermal or thermochemical processes for transporting energy, and thermal energy storage.

The specific FY 1986 activities that will be conducted are:

- Heat Engines ($2,300,000)

  Heat engines convert thermal energy into mechanical work. In a parabolic dish electric system, the engine drives a generator to produce electrical power. Organic Rankine, Stirling and Brayton cycle engines have received continuing solarization support because of their suitability for dish electric module applications.

  The hybridization of a heat engine, adapting a solarized engine for both solar input and fossil fuel-fired, offers the major benefit of constant power output under low insolation conditions, and may be a cost-effective option. This combination also offers opportunities for early market applications of parabolic dish systems and thus would accelerate the deployment of proven systems. In FY 1986, evaluations will continue on a dish electric (engine and concentrator) and trough system to obtain performance data on solar/fossil hybrid units.

  The solarized automotive Brayton engine will continue to be evaluated. Either Rankine or Stirling engines or both will be employed in the two Small Community Solar Experiments. Support will be provided as required in the area of engine development to ensure adequate performance of those devices. Stirling engines may require more attention than had been anticipated because of restrictive licensing agreements that have surfaced with regard to the existing engine.

An advanced Stirling engine for parabolic dish applications, the free-piston Stirling, would be supported if NASA's Space Power Demonstrator Engine experiments in FY 1985 are successful. Sodium heat engines and other energy conversion concepts are potential alternatives to Rankine, Brayton, and Stirling engines for dish electric applications. These possible alternatives will be evaluated as to their long-range potential in meeting energy performance goals. If feasible, these alternatives could increase reliability and reduce the operating and maintenance costs associated with rotating machinery.

- Direct Conversion Devices ($1,000,000)

  This area supports basic direct conversion devices, photochemical and thermochemical research, Photochemical research refers to the use of thermal energy provided by sunlight to drive heat absorbing reactions. This is a promising new application of solar thermal technology. Photochemical research will be directed toward studying the effects resulting from the absorption of photons by matter. In addition, feasibility analyses will be made of selected thermochemical cycles. Splitting the spectrum of incoming solar flux, such as separating thermal and direct photon energy and utilizing the different effects, appears to have merit. In FY 1986, research will be directed toward exploring this potential application. Evaluations of regenerative electrochemical devices for solar thermal applications will continue.

- Transport and Storage ($1,200,000)

  Thermal energy transport and storage systems are important in all systems involving conversion of solar radiation to thermal energy because of the intermittent nature of sunlight falling on the collecting surfaces. Energy transport for Solar Thermal systems requires high efficiency due to the high concentrations. Thermal energy storage can smooth out transient periods of low insolation, extend the period of power operation and permit taking advantage of load shifting economics. Storage is particularly important for central receiver systems and would permit capacity credits, which are related to current incentives, for electricity produced from solar thermal systems.

  In FY 1986 efforts will be devoted to the definition and optimization of advanced high temperature storage concepts for central receiver systems. The application of thermochemical energy transport and long-term storage to distributed receiver systems would continue to be evaluated.

Systems Technology Research ($9,700,000)

The objective of this program element is the development of system studies and parametric analysis at an early stage to assess the economic potential of alternate concepts, and to define critical technology and component issues. This research effort includes the evaluations of existing designs, components, subsystems and systems. Support for small-scale engineering experiments and pilot plants are included as necessary to achieve program goals.

The specific FY 1986 activities to be conducted are:

- Innovative Concepts ($1,200,000)

  This area has as its objective the investigation of innovative concepts and new applications which have the potential of contributing to meeting the long-range goals of the program and the defining of new applications for solar thermal technology. Priority is given to concepts which, although high-risk, could significantly reduce the cost of systems or components. Efforts are made to involve a wide range of researchers outside of the national laboratories in this endeavor. The university-based research program will be expanded and the selective development of innovative concepts such as the synthesis of ammonia using solar energy will be pursued. Following the exploratory research stage, those concepts showing the most promise would be funded for further research.

- Balance of Plant ($500,000)

This task area addresses the characterization and optimization of non-solar components necessary to operate and maintain a complete solar system. Specific activities concentrate on control studies, in addition to automation and maintenance for central receiver systems and distributed receiver systems in order to increase performance and reduce operation and maintenance requirements.

A control concept for unattended operation of either a central receiver system or a parabolic dish system will be selected and a design initiated. Efforts will also be applied to optimal control of multiple dish installations using the Small Community Solar Experiments. The two previously initiated Small Community experiments are the only multi-module dish- electric installations planned and provide an opportunity for field evaluations.

- Central Receiver Systems ($3,500,000)

Central receiver systems research includes the development of designs, the analysis of system parameters, and the experimental testing and evaluation of complete systems. The integration of components and subsystems into complete systems is necessary to properly analyze cost and performance trade-offs, and to identify critical research needs and technology development requirements. Specific activities in FY 1986 will be the expansion and extension of molten salt testing at the Central Receiver Test Facility (CRTF), operation of the CRTF to support system and advanced heliostat evaluations, conceptual design of solar/fossil hybrid suitable for central receiver applications, advanced cycle studies, and cooperation in cost-shared international projects for advanced applications of solar thermal energy.

Central receiver systems, using molten nitrate salts as the heat transfer fluid in the receiver, represent the next generation of central receiver systems beyond the water/steam system typified by the Barstow solar thermal pilot plant. This advance is required to achieve economical energy production. Molten salt system testing was initiated with the Molten Salt Electric Experiment at the CRTF in FY 1984 and continues with receiver, pump and valve testing in FY 1985 under a cost-shared contract with industry. Industry interest is high in the expansion of system testing at the CRTF as an approach for reducing the technical risks associated with central receiver systems.

- Distributed Receiver Systems ($1,300,000)

The objective of this activity is the development of parabolic dish and trough solar energy systems that can produce thermal energy for heat and electricity applications at costs competitive with conventional energy sources. Elements of this effort include concept definition, system layouts, application analyses, integration of components into complete systems, and subsystem and system level experimental testing. FY 1986 activities include systems analysis and testing to integrate advanced components into viable systems, and operation of the Distributed Receiver Test Facility (DRTF). The DRTF is needed for the testing and evaluation of advanced concentrators, heat engines, and distributed receiver subsystems and systems.

Activities also include the integration of improved technology into current line-focus systems, and the evaluation of advanced receivers and concentrators. Distributed line-focus systems for process heat applications represent a near-term opportunity to bring a solar thermal technology to a level where the U.S. industry can successfully commercialize the technology. Research on line-focus improvements is considered critical to achieving the process heat goals.

- Systems Experiments ($3,200,000)

Systems experiments at user sites provide valuable data on capital costs, performance, and operations and maintenance of solar thermal systems.

Experiments are conducted with significant cost-sharing from equipment manufacturers and potential users. Such experiments support the achievement of technical and economic feasibility and are intended to provide the final impetus for industry to commit to full development of the technology. No new starts are planned in FY 1986. Continuing activities include participation under the Cooperative Agreement Contracts in the 10MWe Solar Thermal Pilot Plant at Barstow, CA, the Small Community Experiments at Osage City, KS, and Molokai, HI., and data evaluation for the Shenandoah Total Energy System at Newnan, GA.

Planning and Assessment ($1,000,000)

The objective of this activity is to conduct program integration, assessment, comparative analysis and specific technology transfer activities such as program documentation, work-shops, and periodic contractor review meetings. Solar thermal cost assessment and energy projection activities will be continued to support implemementation of a Five-Year Program Research Plan.

Capital Equipment ($300,000)

The funding requested will provide the test equipment to conduct laboratory and field testing of solar thermal research and development activities.

KEY ACTIVITY SUMMARY
Department of Energy
FY 1986 BUDGET REQUEST

SOLAR THERMAL ENERGY
(B/A in $1000)

KEY ACTIVITY	ESTIMATED ACTIVITIES DURING FY 1985	PLANNED PROGRAM ACTIVITIES FOR FY 1986
Collection Technology Research		
Optical Materials	Conduct research on silvered and transmitting polymers and structural membranes and lightweight structures. Initiate small scale experiments on polymeric reflectors. Validate optimal quality, stability and weatherability. ($1,445)	Identify and characterize reflecting materials, degradation mechanisms in polymers, high absorptivity coatings high temperature measurements. Initiate an evaluation into failure mechanisms of optical surfaces and investigate innovative reflector concepts. ($2,300)
Concentrators	Initiate designs of stressed membrane heliostats. Initiate R&D of three innovative dish concentrators ($6,175)	Continue heliostat research with advanced prototype design, testing and evaluation of innovative dish concentrators. Research on low cost advanced trough concentrators. ($4,800)
Receivers	Investigate important characteristics of high temperature receivers and complete conceptual designs. Characterization of carbonate salts and validate properties and containment materials. Research on ceramics and innovative approaches to resolving solar unique materials problems. ($4,812)	Research on problems with tube and cavity-type receivers. Continue design and evaluations of advanced receivers. Investigate mechanisms of solar induced degradation in ceramics and development of a high flux reactor. ($5,800)

KEY ACTIVITY SUMMARY
Department of Energy
FY 1986 BUDGET REQUEST

SOLAR THERMAL ENERGY
(B/A in $1000)

KEY ACTIVITY	ESTIMATED ACTIVITIES DURING FY 1985	PLANNED ACTIVITIES FOR FY 1986
Conversion Technology Research		
Heat Engines	R&D of advanced Stirling and solarized Brayton engines. Support to Rankine engine development as required for the Small Community Experiment. Investigate novel heat engines approaches. ($2,984)	Evaluation of novel engines--Sodium Heat Engine and others. Increase support of an alternate Stirling engine. Evaluation of Solarized Automotive Gas Turbine engine. Support to Small Community Solar Experiments as required. Evaluate solar/fossil hybrid engines. ($2,300)
Direct Conversion	Photochemical and thermochemical research for direct conversion applications of solar. Investigate potential direct conversion devices. ($1,150)	Continuation of ongoing direct conversion devices, photochemical and thermochemical research. Feasibility analysis of selected thermochemical cycles for possible development. Explore benefits of splitting solar spectrum. ($1,000)
Transport and Storage	Initiate verification experiments of potential energy transport techniques. Examine the concept of solid particle heat storage for central receivers. ($1,300)	Initiate proof-of-concept experiment of thermochemical transport for distributed receiver systems. Evaluation of advanced high temperature storage requirements for central receiver systems. ($1,200)

KEY ACTIVITY SUMMARY
Department of Energy
FY 1986 BUDGET REQUEST

SOLAR THERMAL ENERGY
(B/A in $1,000)

KEY ACTIVITY	ESTIMATED ACTIVITY DURING FY 1985	PLANNED PROGRAM ACTIVITIES DURING FY 1986
Systems Technology Research		
Innovative Concepts	Characterization of solar unique processes and innovative concepts research. Small Business and university research programs. ($2,393)	Continuation of ongoing program to investigate innovative concepts and new applications which have the potential for reducing the cost of components and systems. Research of selected innovative concepts. Includes Small Business and university research program. ($1,200)
Balance of Plant	Design, install and evaluate advanced control system at the Molten Salt Electric Experiment (MSEE). Initiate preliminary analysis of improved controls for DR systems. ($1,540)	Evaluate advanced controls and plant automation for CR systems. Investigate advanced DR system control concepts. ($ 500)
Central Receiver (CR) Systems	Testing and evaluation of the Molten Salt Experiment. Select potential electric or high temperature heat applications and initiate conceptual system design and economic evaluations. CRTF operation for molten salt experiments and heliostat evaluations. ($4,500)	Conceptual design of a solar/fossil hybrid for CR applications, advanced cycle studies and cooperation in international projects. Continue evaluation of molten salt experiment. CRTF operation for molten salt experiments and advanced heliostats evaluation. ($3,500)

KEY ACTIVITY SUMMARY
Department of Energy
FY 1986 BUDGET REQUEST

SOLAR THERMAL ENERGY
(B/A in $1000)

KEY ACTIVITY	ESTIMATED ACTIVITY DURING FY 1985	PLANNED PROGRAM ACTIVITIES DURING FY 1986
Distributed Receiver (DR) Systems	Analysis and evaluation of advanced components and systems operation for Rankine module testing and concentrator evaluations. ($1,255)	Conceptual design of solar/fossil hybrid applications. Cooperation in international projects. Continuation of systems analysis and evaluation of advanced systems. DRTF operation for Small Community module verification tests and advanced concentrator evaluations. ($1,300)
Systems Experiments	Initiate Power Production Phase of 10MWe Pilot Plant. Complete data evaluation of test and evaluation phase. Initiate design effort on Small Community Experiments. ($5,650)	Continue participation and evaluation in the 10 MWe Solar Thermal Pilot Plant Cooperative Agreement and the Small Community Experiments Coopoerative Agreements. Complete data evaluations of the Shenandoah Total Energy. ($3,200)
Planning and Assessment	Program integration, analyses, and Multi-Year Research Plan implementation. Technology Transfer activities. ($1,516)	Comparative analysis, assessments and program integration activities, Technology Transfer activities. ($1,000)
Capital Equipment	Capital Equipment ($ 500)	Capital Equipment, laboratory and field test equipment. ($ 300)
Total Solar Thermal	$35.220	$28,400

Biofuel Energy Systems $28,400,000

The President's FY 1986 request of $28,400,000 represents a $2,420,000 decrease from the FY 1985 appropriation.

Short-Rotation Intensive Culture $4,700,000

The purpose of this program element is to increase significantly the amount of woody biomass that can be grown in targeted areas through increased productivity and increased cost efficiency. Classical genetic selection/hybridization techniques will be used and opportunities examined for application of innovative genetic engineering technology to improve short-rotation woody species. Internal Departmental studies and independent analyses have identified production research as an area of high priority; short-rotation intensive culture offers the greatest potential energy payoff among production technologies under consideration. Successful realization of that potential requires research to identify, select, genetically improve, and field test woody plants for short-rotation.

FY 1986 funding will be used to examine experimental plantings and to determine potential yields and risks associated with growth and successive resprouting of short-rotation intensive culture. Data will be obtained on the number of growth harvests that can be performed before yields start to decline and replanting is necessary. Monoculture viability studies will be conducted to determine possible pest and disease problems that might occur during the life cycle of a single species hardwood stand. Industry will be cost-sharing 20% of this research. Research will make use of existing plantings which are specifically designed to define and identify methods to decrease technical and operating risks ($3,000,000).

Genetics research will be conducted to increase the potential of promising short-rotation species by creating genetic hybrids which promote higher biomass production either by expanding the range and sites in which a species can be grown, or by increasing resistance to pest and disease. Complementary research to understand the physiological and morphological basis for highly desirable variants will be conducted. These studies make it possible to identify and control the basic factors influencing productivity. Research will also focus on breeding and physiological studies utilizing tissue culture techniques which permit a more comprehensive evaluation of a wider variety of species for high productivity and site adaptability ($1,700,000).

Industry participation in the Short-Rotation Intensive Culture Program has continued to increase since its inception. With a continued active technology transfer program, it is anticipated that industry's cost-sharing of short-rotation intensive culture research will continue to grow. Technology transfer activities will be an integral part of the FY 1986 program.

Production Research $3,600,000

The purpose of this program element is to establish the technology data base in order to develop the potential of aquatic and herbaceous energy crops as sources of alternative fuel. Numerous studies, including the Department's own, have identified production research as a high priority area of research. Herbaceous and aquatic plants offer the potential to increase biomass energy supplies by providing high yields of biomass on marginal land, including semi-arid lands and coastal areas. Research will focus on selection of species, quantity and quality of the energy product, improvements in productivity, field performances, and response to management and cultural practices.

For herbaceous species, experiments will be conducted to identify species capable of producing biomass for energy on marginal croplands. Field trials will be located in the Midwest, Lake States, Southeast, and Plains States to measure species performance in terms of productivity and survivability. Research will also be conducted on selected herbaceous oilseed species for diesel fuel alternatives. Field tests will be conducted to improve their potential by evaluating hybrids that have been developed for desired fatty acid composition which increases their fuel value. Seed productivity, ease of management, and survivability will be examined. For hydrocarbon bearing plants, studies will be conducted to understand hydrocarbon synthesis pathways in promising plants. This research will be designed to determine whether methods for increasing hydrocarbon production can be developed ($1,100,000).

Technical experiments for selected herbaceous species, as determined from previous research, will be evaluated on small-scale experimental plots of less than five acres. The research will be designed to evaluate the candidate species' performance under the best known establishment and cultural techniques. Equipment requirements and biological or technical risks such as pest damage and disease will be defined ($500,000).

Screening of microalgal species will be conducted to provide the full set of data required to enable selection of microalgal species that show high potential for oil production. Temperature, pH, salinity, and media requirements will be defined along with the proximate chemistry and energy content of each species. The general physiology of species having broad tolerance to these parameters, as well as a favorable general chemistry, will be examined. This will detail nutrient preference, define uptake kinetics, establish the limits to which species can adapt to temperature, pH and salinity levels and their variations, determine light requirements, and test for photorespiration. Properties and composition of oils and lipids will also be determined ($600,000).

Genetics research will be accelerated to focus on the use of genetic selection and improvement techniques to improve oil product synthesis, increase growth rates, improve temperature tolerance, enhance the utilization of incident light and improve harvestability and processability of selected microalgal species ($900,000).

For aquatic species, two small scale experimental units will be operated testing management approaches and design adaptations. Results will contribute input toward the development of prototypic system designs through ongoing analysis of the technology. Technology transfer activities relating to production research will be conducted as an integral part of the program ($500,000).

Thermochemical Conversion $9,400,000

Included in this budget is $5,000,000 for scale up of a promising medium Btu gasification process. In FY 1986, industry cost sharing is projected to be 25% of the entire thermochemical conversion program (includes research as well as medium Btu scale-up).

The purpose of this program element is to provide research data that could lead to cost-effective heat processes for conversion of biomass into clean fuels. Research is focusing on improvements for the thermochemical conversion of biomass to gaseous fuels, using woody and herbaceous crops and agricultural residues. FY 1986 funding will be used to obtain increased knowledge of gasification concepts, as well as provide for a cost-shared medium-Btu scale-up. The FY 1986 program emphasis on medium-Btu gasification is consistent with studies which identify medium-Btu gasification as an area of high priority. Gasification technologies offer the added benefits of ready substitution for conventional fuels and applications in many sectors of the economy. Thermochemical conversion technologies use renewable feedstocks; therefore, they offer the potential for a secure, relatively inexhaustable supply of energy. It should be noted, however, that the potential of thermochemical conversion is tied directly to the availability of biomass feedstocks.

Thermochemical gasification research affords the potential of contributing between 2.5 and 5.7 quads of energy in the form of medium Btu gas according to recent estimates. This research comprises the major thrust of the thermochemica conversion subprogram and is expected to result in private sector use in the mid-term timeframe.

In an effort to gain crucial data and define technical and operational boundaries of larger-scale medium Btu gasification technology, a cost-shared experimental facility will be constructed. This 50-200 tons/day facility is designed to show the capability of producing gaseous fuels from a number of biomass feedstocks. It will serve as a centerpiece for the biomass conversion program. The facility will be cost-shared by industry. Federal investments will be limited to high-risk elements of design, construction and early operation of the scaled-up facility. Industry will be expected to use the technical data obtained from this project to further develop medium Btu gasification technology ($5,000,000).

FY 1986 funding will also be used to support medium-Btu gasification technologies currently in the early stages of research. Experiments will be conducted to optimize process conditions, determine process design requirements, and identify parameters for each process. Gasification experiments have been focusing on those processes industry has shown an interest to cost-share. Additional research will exploit prior findings on ceramic and metal fire-tube heat exchangers for gasification processes. Research will investigate effects of bed hold-up, recycle gas, and feed location on the gasifier. Waste stream research will characterize tars and waste streams containing dissolved organic liquids which are produced in gasification processes, and develop methods for mitigating their costs of disposal ($1,900,000).

Municipal waste research focuses on obtaining a basic understanding of the thermal process involved in the conversion of municipal solid waste (MSW) to fuels. Research will involve analytical studies and experimental laboratory scale investigations under controlled conditions. In coordination with EPA and the American Society of Mechanical Engineers, research on the formation of trace organic substances (dioxins) will be performed. Efforts will focus on understanding the reaction mechanisms in MSW gasification/pyrolysis and on identification of reactor designs that will allow the proper heating rates and conditions for MSW feedstocks. Data will be gathered from a large-scale, fully instrumented MSW combustor to provide a scientific basis for the design of more efficient, economical, and environmentally sound facilities by industry. Other efforts provide base-line data for storable and transportable solid fuels from MSW and for industrial development of small-scale processing equipment which will increase the MSW available for use by 15 to 25%. Research will allow the program to aggressively pursue critical research needs that have been identified by the resource recovery industry ($2,500,000).

Biochemical Conversion	$8,100,000

The purpose of this program element is to establish the technology data base for biochemical conversion of cellulosic and lignocellulosic feedstocks to liquid and gaseous fuels. The understanding of the microbiology and biochemistry of biological processes will allow for improvements in conversion efficiencies and improve the technical and economic viability of processes for production of alcohol fuels and methane. FY 1986 funding will be used to overcome problem areas and reduce the technical risks associated with fermentations and anaerobic digestion of renewable feedstocks. Technical uncertainties in alcohol production from lignocellulosics (woody stock) have restricted industrial support of this area. Anaerobic digestion of the cellulosic fraction of municipal solid waste is also an area with significant risks and limited private sector involvement. Private sector development of these technologies will not occur without advancements in pretreatment, conversion efficiencies, and product recovery.

FY 1986 funding will be used for development of improved organisms with superior capability for hydrolysis and fermentation. Genetic engineering techniques, including recombinant DNA techniques, will be used to generate stable and hardier strains with increased enzymatic activity and enhanced ability to convert the hemicellulose fraction to ethanol. Work will continue to identify organisms which can hydrolyze cellulose and hemicellulose to sugars and then ferment the sugars, including the pentoses, to ethanol. In FY 1986, an acid recovery system will be incorporated into the TVA test bed facility which is designed for small-scale testing of integrated ethanol fuel systems. Integrated technology experiments will be conducted with specified pretreatments and ethanol-producing organisms to show subsystem compatibility ($5,500,000).

For methane production, research will focus on the basic physiology and biochemistry of anaerobic microorganisms to develop a sound technology data base. Plans are to investigate efficient digester and injection concepts for processing high solids concentration of municipal solid waste feedstock. Laboratory results from high solids experimentation will be evaluated in the anaerobic digestion test-bed facility. Research will be undertaken to investigate the types, spatial relationships, and microbial populations in sanitary landfills. Research will also stress the accelerated development of anaerobic bacteria microbial strains, using advanced genetic manipulation techniques that will markedly improve methane yields and reduce residence times for MSW bioconversion systems, and pursuit of several presently theoretical techniques that can substantially increase the energy efficiency of municipal waste water treatment facilities. Technology transfer will promote the utilization of research and technological advances to stimulate industry to develop biochemical conversion technologies ($2,600,000).

Regional Biomass Energy Program	$2,000,000

The purpose of the Regional Biomass Energy Program is to promote the transfer of biomass energy production and conversion technologies to the private sector based on the resources and energy needs of different geographic areas.

FY 1986 funding will be used to continue work in four regions (Pacific Northwest, Northeast, Great Lakes and Southeast) where the management structure is already in place and long-range plans have been developed. This program serves as a vehicle to involve the non-Federal sector in biomass energy development. To that end, cost sharing is a major part of the program; the individual states in each region, as well as the private sector, participate in cost-sharing arrangements with each region.

The focus of the regional program is on reducing or eliminating the barriers to increased biomass use. These include technical barriers (e.g., state-of-the-art of biomass energy technology), institutional barriers (e.g., availability of state and local financial incentives), supply barriers (e.g., lack of an identifiable and reliable fuelwood supply infrastructure), safety barriers (e.g., need for standards and codes), and environmental barriers (e.g., air pollution). The primary focus of the program is on transferring the technical results of biomass energy research to industry.

Capital Equipment	$600,000

Capital equipment funds will be used for acquisition of laboratory apparatus and equipment necessary to support research across the feedstock production and conversion programs.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY

Biofuels Energy Systems
(B/A in $1000s)

Key Activity	Estimated Activity During FY 1985	Planned Program Activities During FY 1986
Short Rotation Intensive Culture	Conduct culture research, genetic selection, tissue culture experments, and nitrogen fixation research. ($4,200)	Conduct genetics, tissue culture, hybridization research; conduct monoculture research. ($4,700)
Production Research	Conduct generic research for energy applications and technical proof-of-concept experiments; use genetic techniques to increase productivity. ($5,970)	Carry out generic research for energy applications, technical proof-of-concept experiments and genetic research. ($3,600)
Thermochemical Conversion	Conduct experiments on process research gasifiers; conduct cold flow model testing. Conduct research on reactor design, product upgrading catalysts, and process conditions. Carry out liquid fuels research, and combustion research on biomass and municipal waste. ($11,150)	Scale-up medium-Btu gasification process. Conduct medium-Btu gasification research and thermochemical conversion of municipal waste research. ($9,400)
Biochemical Conversion	Conduct acid and enzymatic hydrolysis experiments, as well as integrated technology experiments for liquid fuel production. Conduct research on the anaerobic digestion of cellulosics and municipal waste. ($4,500)	Conduct acid and enzymatic hydrolysis and integrated technology experiments and anaerobic digestion of municipal wastes. Develop microbial strains for municipal waste bioconversion. ($8,100)
Regional Program	Funds regional technology transfer activities in Northeast, Lake States, Southeast, and Pacific Northwest. ($4,000)	Funds regional activities in four regions. ($2,000)
Capital Equipment	Laboratory apparatus for microalgae and integrated enzymatic hydrolysis experiments. ($1,000)	Laboratory apparatus for experiments in biomass production and conversion technologies. ($600)
TOTAL BIOFUELS	$30,820	$28,400

Wind Energy Systems $20,800,000

The FY 1986 request for Wind Energy Systems is $20,800,000, and it represents a $8,080,000 decrease from the FY 1985 appropriation.

The principal objective of the Wind Energy Program is to improve the understanding of fundamental atmospheric processes affecting wind turbines and their aerodynamics and structural dynamics and to translate this understanding into tools that industry can utilize to design and operate cost-competitive turbines.

Program planning for FY 1985 and the FY 1986 budget request reflect a growing government/industry partnership. Thousands of small wind turbines are now operating in California windfarms, most installed during late 1983 and 1984. Industry is now moving towards larger machines. The results of industry/government R&D planning meetings held in April and May 1984 indicate that the industry sees an urgent need for improved aerodynamics, turbulence and structural dynamic theories and a requirement to develop better design tools. The priorities reflected in this budget are a direct result of areas identified in these "open forum" meetings as urgent needs for the technology base. Highest priority activities cited were nonsteady aerodynamic computer codes, structural dynamics models, materials properties and fatigue life research, advanced subsystems, wind turbulence characterization and wake technology.

The FY 1986 request is structured to address these issues through research in industry, government, and university laboratories, while at the same time pursuing cooperative field test programs on windfarms and industry-sponsored prototypes. To that end, the FY 1986 request will support a major cooperative program with developers and operators of windfarms to test and evaluate aerodynamics, structural loads, blade material properties, atmospheric turbulence, and flow/wake models. This capitalizes on an opportunity not previously available to the Federal wind program. Research testing will also be continued in wind tunnels and using the Mod-2 large scale turbines and experimental test beds.

Aerodynamics Research $9,200,000

Understanding the atmospheric physics of wind and wind turbine rotor interaction is fundamental to advancements in the wind technology base. Major areas of emphasis include unsteady flow and aeroelastic theory, atmospheric fluid dynamics, improved airfoils, aeroacoustic research, aerodynamic control methods, and cooperative testing with manufacturers and wind turbine developers. Research will address both horizontal axis (propeller-type) and vertical axis (Darrieus-type) machine configurations.

o Unsteady Flow and Aeroelastics ($2,600,000)

  The unsteady nature of the wind and the airflow along and over wind turbine blades are now believed to cause unexpectedly large aerodynamic loads and to affect significantly energy capture and operating lifetime. Aeroelastic theory is being extended to more accurately describe the interaction of the air and the motion of the turbine blades. Existing aerodynamic and aeroelastic models assume a steady, non-time varying flow over an airfoil in a two dimensional system. However, cyclic lift and drag forces predicted by these codes are often low by a factor of two. The requested funding would support continued research in dynamic stall, three dimensional flow, and development of advanced computer codes through wind tunnel testing, flow visualization and experimental testing.

o Atmospheric Fluid Dynamics ($2,300,000)

  Atmospheric fluid dynamics is the science of wind flow, wind turbulence, wake inducement, and vortex generation and the effects these have on structures. They impact wind turbine design, performance and lifetime. Understanding the wind that a rotating wind turbine blade encounters is critical to improved aerodynamics, structural dynamics and fatigue prediction. Research results have shown that a rotationally-sampled wind produced higher structural stresses than predicted by a single point wind. The structure of the turbine wake strongly affects interturbine spacing and structural loads, and effects of complex terrain on wind flow can produce significantly different power from nearby turbines. The requested funding would support theoretical and experimental studies of wind turbulence, wake studies, and cooperative projects on wakes and terrain effects with windfarm developers, and development of wind resource extrapolation techniques for estimating turbine performance where detailed data are unavailable.

o Airfoil Characterization ($1,200,000)

The wind turbine airfoil has a major effect on turbine performance. Wind tunnel data on helicopter and fixed wing aircraft airfoils are not directly applicable to wind turbine blades since the rotor elements of the wind turbine operate at lower air speeds and considerably higher angles of attack. However, data of this type is vital to wind turbine designers. Funding requested will support continued research on generic families of airfoils with improved performance while minimizing structural stresses.

o Aeroacoustic Research ($600,000)

The unsteady airflows over a rotor produce both noise and varying structural stresses. Requested funding will support continued development of a model to predict unsteady aeroacoustic noise and will include wind tunnel and atmospheric tests to determine correlation of rotor noise with structural loads and to develop quiet airfoils.

o Advanced Control Concepts ($500,000)

Control of a wind turbine to prevent overspeed, moderate torque changes and limit power is essential to satisfactory operation. The pitch control mechanism in a horizontal axis machine is a major component and often troublesome. No mechanical blade pitch control is currently practical in a Darrieus vertical axis system. Requested funding will continue investigation of control concepts such as aerodynamic braking and pumped spoiling of airfoil lift as methods for controlling rotor speed, achieving emergency braking and enhancing peak power on future machines.

o Cooperative Programs with Wind Turbine Manufacturers and Developers ($2,000,000)

With the emergence of numerous windfarms in California and elsewhere, theories of wind turbine wakes, spacing, performance, loads, fatigue life and power quality can now be validated in field tests. Requested funding will provide for continuation of cooperative research with manufacturers of turbines and windfarm developers to continue building the aerodynamics and structural dynamics data base needed to validate theoretical concepts and computer codes. It is anticipated that cost-shared projects with several manufacturers and developers will be initiated in FY 1985 on a competitive basis, and will be continued in FY 1986.

Structural Dynamics Research ($7,100,000)

A wind turbine is a complicated, interrelated system whose structural dynamics must be thoroughly understood and whose structural elements must be carefully designed. Information learned to date has shown that structural interactions with the incoming wind turbulence, complex three dimensional flow, and unsteady boundary layer interactions produce higher-than-previously predicted loads. These loads have a major fatigue effect and significantly reduce lifetime.

The objective of the structural dynamics research is to develop and validate models, and provide computer codes to enable industry to design wind turbines with 20-30 year design life.

Major areas supported include research on improved structural dynamics models for predicting stresses and natural frequencies, verification of those models, investigation of wind turbine power dynamics, complete construction of an improved vertical test machine, and initiate design and construction of a new improved experimental machine for horizontal axis systems research. The majority of this work is generic research with no immediate payoff to industry and consequently unsuitable for cost-sharing. When industry-sponsored turbines are used to validate structural codes, cost-sharing will be sought.

o Frequency and Time Domain Models ($1,200,000)

Existing structural predict dynamics models are extremely complex to use and do not adequately predict the wind turbulence that influences fatigue life. Requested funding will support validation of forced dynamics models for vertical and horizontal axis systems, with emphasis on appropriate configurations in the intermediate-size range, 100 kW to 500 kW, which is of most interest to industry.

o Improved Experimental Test Bed Capability ($3,800,000)

Flexible experimental test beds are required to support the vertical and horizontal axis research efforts. Funds are requested to complete construction of an improved vertical axis test bed begun in FY 1985 and to initiate construction of a horizontal axis test bed to replace the Mod-0. The present horizontal axis test bed (the Mod-0) is no longer efficient as an experimental facility. Airfoil changes require considerable cost and down time, key load and performance parameters are difficult to monitor, and extremely soft tower models cannot be accurately simulated. Funds are requested for design of a more flexible test bed to meet industry's request to expedite experimental evaluation of rotor augmentation systems, new airfoils, rotor control techniques, and drive-trains using modern data acquisition systems. Operations of the existing Mod-0 will be continued on a limited basis until the new machine is available in FY 1987.

o Turbine Power Dynamics and Control ($2,100,000)

Wind turbines are considerably different generation sources from conventional power plants, the energy output can vary significantly and the drive train is much softer than conventional generators. The implication of these differences is that the effects on the host utility grid can be very different. The requested funding will provide for completion of Mod-2 electrical system tests at Goodnoe Hills, WA to determine wind turbine stability, response after power line fault, and interaction among the three turbines. Data on megawatt size machine performance and structural loads will be collected at other sites for comparison with data from Goodnoe Hills. A wind/diesel study, recommended at the industry planning meetings, will also be continued.

System Analysis ($500,000)

Requirements for future wind technology research are determined from continuing assessment of the technology base, problems being encountered by the private sector and trends, progress and growth in the marketplace. The requested funding provides for continued program planning, industry assessments and analysis.

Wind Energy Research Center	$1,900,000

The wind energy research activities at the Solar Energy Research Institute and the wind energy technology activities and the Small Wind Systems Test Center at DOE's Rocky Flats plant have been merged into one group and program. This combined group, the Wind Energy Research Center, has become part of the Solar Energy Research Institute's organization; however, they will operate from the existing wind test center facility located at Rocky Flats. The new combined Wind Energy Research Center will perform broad based research and testing to address questions relating to both small and intermediate sized machines and is expected to become a focal point for wind energy research and technology in the U.S. The Wind Energy Research Center at Rocky Flats will continue to offer manufacturers access to analytical and experimental facilities, such as dynamometers, data acquisition systems, and controlled-velocity test systems and test beds not otherwise available. The funding requested is needed to maintain an experienced technical staff at the test center and to provide field test capability.

Advanced Multimegawatt Turbine (Mod-5B)	($1,300,000)

o The FY 1986 budget request is to support an orderly close-out of the cost-shared Mod-5B advanced multi-megawatt wind turbine program. The requested funding would permit completion of detailed design and related development testing. Hardware fabrication contracts will be discontinued. The documented Mod-5B design will incorporate new technology and advanced features that represent a significant improvement in terms of performance, cost and reliability over current wind turbine systems. The completed design and the development test results will be available to industry for use in commercial developments.

Capital Equipment	($800,000)

The FY 1986 budget request for capital equipment is $800,000, a $600,000 increase over the FY 1985 Appropriation. This increase is necessary to provide for research data acquisition equipment on the improved vertical and horizontal axis test-beds, as well as on-site at various windfarms and test sites under the cooperative program.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY

Wind Energy Systems
(B/A in $1000)

Key Activity	Estimated Activity During FY 1985	Planned Program Activities During FY 1986
Aerodynamic Research	Continue research on unsteady flow, aeroelastics, atmospheric physics and environmental issues. Initiate major cooperative program with windfarm developers and manufacturers. ($7,780)	Continue research to extend unsteady airflow and aeroelastic theories, develop improved airfoils, validate wake flow and turbulence models. Continue cooperative program to validate models with windfarm developers and turbine manufacturers. ($9,200)
Structural Dynamics Research	Continue development and validation of structural simulation models, fatigue life models, and complete Mod-0 variable speed generator testing. Initiate construction of advanced vertical axis test bed. ($5,500)	Continue basic research to improve and validate structural models to predict stresses and natural frequencies, and complete construction of the advanced vertical axis test bed. Initiate development of a new horizontal axis test bed to replace the outdated Mod-0. Initiate investigation of wind turbine power dynamics. ($7,100)
Wind Energy Research Center	Continue generic research and fee-paid testing and consolidate Rocky Flats staff with SERI. ($1,700)	Continue fee-paid testing and increase generic research at the combined Wind Energy Research Center. ($1,900)
Systems Analysis	Continue R&D planning, analysis and assessments. ($700)	Continue R&D planning, analysis and assessment. ($500)
Mod-5	Continue cost-shared Mod-5B Program. ($13,000)	Complete supporting research and close-out of Mod-5B. ($1,300)
Capital Equipment	Data acquisition equipment for laboratories. ($200)	Data acquisition equipment for test beds and cooperative programs. ($800)
TOTAL WIND	$28,880	$20,800

Ocean Energy Systems $3,500,000

The President's FY 1986 budget request for Ocean Energy Systems is $3,500,000. This represents a decrease of $980,000 from the FY 1985 appropriation.

Materials & Structures
Research $600,000

The purpose of this program element is to develop techniques for technical risk and life cycle cost reduction in ocean structures and ocean construction materials. Research into new materials and deep ocean structural design concepts will be continued from FY 1985. A composite Fiberglass-Reinforced Plastic (FRP) cold water pipe (CWP) structure has been designed and deployed on a steep underwater slope off the island of Hawaii. Instrumentation on this CWP is currently recording pipe stress and strain, response to environmental loadings, and environmental conditions. This data will be of significance in the determination of CWP performance characteristics. It will be crucial to the evolution and experimental verification of a predictive model required for private sector design of coldwater pipes for Ocean Thermal Energy Conversion (OTEC) land based and shelf- mounted plants.

The FY 1986 budget request will provide funds to continue research into new materials for construction of CWP's. A necessary step of this research, required for meaningful technology transfer to the private sector, will be the overall validation of computer models (codes) which can then be used by industry to design CWP's for OTEC plants. There has been no cost-sharing for CWP computer code validation and only indirect CWP materials research by industry to date. Industry has yet to acquire the technological data base with which to correlate diverse sets of CWP computer programs. CWP materials research and life cycle testing by industry has been conducted for related commercial products which are not capable of satisfying OTEC design conditions.

- Validation of CWP Computer Codes

  - Research will be conducted to validate CWP computer codes which can be used for the design and performance prediction of OTEC CWP's. To date DOE has developed a diverse set of computer programs (codes) in support of various aspects of the ocean engineering portion of the OTEC R&D program. Completed codes are being entered into the National Technical Information System (NTIS) as they become available for access by industry. Present codes are preliminary and inconsistent in both quality and format. Supporting data for these codes has come from physical model tank tests with simulated ocean environments as well as at-sea tests.

    These CWP computer codes can provide generic design tools for industrial use in the development of OTEC plants. DOE will evaluate the utility of the various codes developed to date. In the course of validation using experimental data, Federal Information Processing Standards will be applied to assure the codes provide computer user friendliness and to enhance utilization by the widest segement of industry.

Experimental Verification
and Testing $1,333,000

The Seacoast Test Facility (SCTF) is property of the Natural Energy Laboratory of Hawaii located on the island of Hawaii. Warm surface seawater and deep cold seawater drawn from the ocean are the principal resources of the SCTF. This seawater resource has supported small scale DOE experiments in biofouling and corrosion research and limited performance measurements of candidate OTEC heat exchanger materials and design configurations. The SCTF represents cost-sharing by the State of Hawaii in the development of ocean energy. Previous capital improvements such as roads and buildings were performed at the State's expense, and the State cost shares in certain ongoing projects and operational costs.

- SCTF Upgrade ($833,000)

  - The critical cold water capabilities of the Seacoast Test Facility will be upgraded. Experimental capability is presently limited by the cold water supply. An increased cold water supply will permit sea water testing of certain components at a more realistic scale, and testing of more components in parallel. Ongoing studies will determine the precise details of the upgrade to be undertaken with FY 1985 and FY 1986 funds.

- SCTF Test Costs ($500,000)

  - This effort will continue DOE cost shared funding at the SCTF for in-situ experimental verification of heat exchanger elements and small scale components which address significant improvements in heat transfer, evaluation of life expectancy and related performance. Funding will cover usage of seawater, electricity, laboratory equipment and supplies, and technical and administrative support personnel from the SCTF.

Thermodynamic Research and Analysis $1,567,000

The purpose of the Thermodynamic Research and Analysis program element is to develop a data base to evolve a set of experimentally verified, analytical, numerical and physical models which can be used to accurately describe the generic phenomenology and performance of ocean thermal energy extraction and utilization techniques. This program will address two methods of ocean thermal energy extraction, closed-cycle and open-cycle, with the emphasis on developing the techniques and generic data base for a supply option in the 1 to 10 MWe range.

CLOSED-CYCLE RESEARCH AND ANALYSIS: Of the two OTEC system approaches to be investigated, the potential systems configuration and energy management scenario for the closed-cycle option is better understood in principle than open-cycle. Targeted research and analysis is required, however, to provide industry with a predictive analytical modeling capability and the thermodynamic data base for an enhanced closed-cycle option within the next five years. A change of performance of a single component or OTEC subsystem impacts the entire power conversion system. OTEC plant size, capital cost and operating cost are affected as well. The result is that major issues remain which need to be resolved in terms of their effect on entire plant performance in order to reduce the technological risk to a more acceptable level for industry. The generic solutions resulting from closed-cycle research will also be applied to open-cycle condenser technology development.

The program has advanced to the point where a number of innovative designs have emerged to enhance the closed-cycle OTEC power system. These designs are unproven and require verification through analysis, laboratory research and testing. Industry is unable to project a rate of return on its invested capital for such designs. It is therefore premature to expect cost sharing until the time the core-issues for the enhanced closed-cycle power system have been resolved. Accordingly, the following activities are planned.

- Advanced Heat Exchanger Development

  - An objective of this activity is the development of a heat transfer technology which will contribute towards an overall system cost reduction. Heat exchanger capital cost is influenced by material and fabrication costs. By increasing the overall heat transfer coefficient, it is possible to reduce the heat exchanger area and the rate of water flow for a given amount of power generated. Trade-off studies are necessary to determine the optimized system that takes advantage of all the cost reducing measures. This includes the improvement of predictive heat exchanger analysis capability from the current 25 percent error range to about 10 percent.

- A second objective of this activity is to explore innovative methods for fabrication, assembly and improvement in the predictive design methods for flat plate heat exchangers with consideration of recently proposed enhancement methodologies for closed-cycle power systems. Conversion processes will be considered which must take into account changed operating conditions for the heat exchanger as the result of waste heat recovery and augmentation scenarios. The program aim is to reduce the estimated cost contribution by heat exchangers from 50 percent of the overall OTEC system cost to 25 percent. This will be attained through reduced energy transfer requirements in the heat exchangers, and partly through the use of materials which previously were not considered because of heat exchanger size constraints.

- In addition, testing of adhesively bonded plastic and metal/plastic test articles in seawater will be undertaken at the Seacoast Test Facility to verify and quantitatively analyze potentially low cost surface heat enchanger approaches.

o Research Applying to both Closed and Open Cycle Systems

  - A number of the tasks that have been identified for the development of OTEC closed-cycle heat exchangers also apply to open cycle surface condensers. These include research on waterside enchancement, biofouling and corrosion, cost performance models, innovative methods for fabrication and assembly of heat exchangers, and improvement of predictive generic design methods.

  - Research on these tasks will be performed at Argonne National Laboratory (ANL). ANL will provide to this effort data received from various heat exchanger test articles furnished by industry at no cost to DOE. Such data and test articles represent a cost sharing by industry.

OPEN-CYCLE RESEARCH AND ANALYSIS: The open-cycle power system has a potential advantage over the closed-cycle OTEC power system inasmuch as it removes heat from the ocean surface water without the loss of efficiency inherent in the use of a secondary working fluid. At some loss in efficiency, relative to direct contact condensing, the use of surface condensers in the open-cycle process offers the potential for simultaneous production of fresh water. The FY 1986 program in open cycle research will involve theoretical investigations of heat and mass transfer. Analysis will be directed toward defining experimental research necessary to refine the mathematical models in heat transfer methodology and uniform heat transfer coding procedures for open cycle systems.

The establishment of an open cycle OTEC industry can only result after the basic research questions are addressed and answered. There is insufficient definition of return on investment for industry to cost share at this time. Research on the heat and mass transfer effects of non-condensible gases and low pressure heat and energy transfer to turbines is needed to furnish this definition.

o Non-Condensible Gas Handling Research

  - Four areas of research will be investigated in FY 1986 and/or FY 1987. These areas are (1) impact of pre-deaeration on system effectiveness, (2) kinetics of non-condensible gas sorption processes, (3) methods for gas concentration in the mass transfer process, and (4) methods for gas removal.

o Turbine Development and Seawater Pumping Research

  - The long-term effects of low pressure steam with high chloride content on turbine blade materials and structures will be investigated. The exposure effects of cold sea water on pipe materials and seawater pumps for extended periods also is to be assessed.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITIES SUMMARY

Ocean Energy Technology Division
(B/A $000)

Key Activities	Estimated Activities During FY 1985	Planned Activities During FY 1986
Materials and Structures Research	Perform research to determine the basic material properties inherent in sandwich pipe construction and operational stress and strain on OTEC structural components. - Assessment of structural dynamics of Fiberglass-Reinforced Plastic Cold Water Pipes. Pipe, Platform and Foundation/ Deployment/Installation Techniques. ($580)	Validate CWP computer codes for the design of cold water pipes. Validation effort to ensure that the codes will provide user friendliness for enhancing industrial utilization. ($600)
Experimental Verification and Testing (STF)	Seacoast Test Facility (STF) modification to increase flows of cold and warm seawater. - Conduct seawater experiments for verification of analytically derived characteristics ($1800)	STF upgrade will be continued to provide the capabilities needed for planned OTEC experiments ($833) DOE will continue to cost-share experiments at the STF. ($500)
Thermodynamic Research	Perform research on thermodynamic characteristics and properties. - Open-cycle research. Complete preparation of an open cycle experiment at the STF Begin seawater experiments at the STF to verify open cycle OTEC analytical models developed from bench scale fresh water experiments. - Thermodynamic Materials Research and Analysis. Perform evaluation and performance/ cost modeling of advanced heat exchanger materials and design. ($1650)	Conduct heat and mass transfer investigations supplemented by experiments addressing critical open cycle performance parameters. Develop and refine mathematical models for heat transfer. ($1250) Experimentally verify analytical, numerical and physical models needed to accurately describe ocean thermal energy extraction and utilization techniques. ($317)
Environmental and Oceanographic Research	Perform research into large water displacement effects and coastal zone interaction ($150)	No funding requested.
Wave Energy	Evaluate existing prototype and/or new concepts ($300)	no funding requested.
Total Ocean	$4,480	$3,500

International Solar Energy Program $0

No FY 1986 funds are being requested for Solar International, representing a $500,000 decrease from the FY 1985 appropriation.

The purpose of this program is to communicate to the world market, the technical and economic attributes of U.S. developed renewable energy technologies. The Department of Commerce and Foreign Service Officer network will be utilized for transmitting this marketing information to a complex and rapidly changing international marketplace. Department of Energy sponsored activities will continue into FY 1986 until all remaining funds have been expended.

In addition, recently an interagency working group has been established, as required by the Renewable Energy Industry Act of 1984. This team of Government officials is exploring with the commercial sector, more effective approaches for marketing U.S. renewable energy technology overseas.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY

Solar International
(B/A in $1000's)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
o International Trade Development	o The Department of Commerce, Foreign Service, and Renewable Energy Export Council will continue to conduct exhibits, trade missions and seminars, and video catalog shows. Responding to Congressional and industry suggestions, DOE will also help improve the coordination of Federal Government supported renewable energy export marketing efforts. ($1,000)	o No new funds are requested. ($0)

Solar Technology Transfer

$3,100,000

The FY 1986 Solar Technology Transfer budget request of $3,100,000 represents a $2,900,000 decrease from the FY 1985 appropriation.

The objective of this program element is to effectively transmit results from DOE sponsored solar energy research to non-Federal sectors for timely technology adoption and further commercial development.

Mandated reports will continue to be prepared. A small series of previously conducted audience analyses shall be used for refining and more effectively targeting program activities to package, publish and distribute solar R&D results in formats suitable for assimilation by users in various economic sectors. Peer review will be intensified, and standing publications are to be reviewed and updated. Wide notification of available services shall also be made to potential users.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY

Solar Technology Transfer
(B/A in $1000's)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
o Technical and General Information	o Prepare mandated reports. Assemble, update, reproduce and distribute technical data and maintain an interface with the research community. Continue toll-free telephone and mailing information services.	o Prepare mandated reports. Implement results of FY 1985 assessments to target program activities more effectively.
	($5,400)	($3,100)
o Technology Transfer Assessments	o Assess the effectiveness of communication efforts to/from the private sector.	o No funding requested.
	($400)	($0)
o Seminars and Worshops	o Organize, conduct and evaluate seminars and workshops on selected solar energy technology topics.	o No funding requested.
	($200)	($0)
TOTAL SOLAR TECHNOLOGY TRANSFER	$6,000	$3,100

Solar Energy Research Institute $2,332,000

An initial budget request for Solar Energy Research Institute (SERI) general application capital equipment is being proposed in this submission. Items totalling $261,000 will serve crosscutting solar energy technology research and general program administration purposes at the SERI site in Golden, CO. Security, machine shop, material handling, instrument calibration, and automated office system needs would be fulfilled by the acquisition of this equipment.

In addition, a total of $2,071,000 in general purpose (GPP) improvements is also requested for the DOE Solar Energy Research Institute site. No similar GPP budget request has been made in the past since DOE's first permanent SERI facility, the Field Test Laboratory (FTLB), was just completed for occupancy in February 1984. The following projects are proposed to provide for the more effective use of Government-owned properties.

o Mesa Top Access Road- This proposed all-weather roadway would reduce round trip travel time by six miles to/from mesa top experiment sites and the Field Test Laboratory Building. The current partially dirt trail can not be used in wet weather.($369,000)

o Two Waste Water Monitoring Stations- Continuous monitoring of waste water effluent is required by regulation at two permanent site discharge points. Monitoring will help evaluate the effectiveness of effluent treatment and control. ($70,000)

o Air Effluent Monitoring Project- The continuous monitoring of eight SERI Field Test Laboratory Building effluent stacks for gases and hydrocarbons is necessary to comply with regulatory requirements. SERI has obtained discharge permits, but the FTLB stacks must be constantly monitored to insure that air pollution limits are not exceeded. ($46,000)

o Security Enhancement- At present, only part of the DOE SERI acreage is fenced. A completed enclosure would restrict public access to building and field test installations, therefore protecting valuable Government investments. ($347,000)

o Power Conditioning System- Sensitive SERI equipment requires stable electrical power. Without power conditioning, experiments at the site will continue to produce erratic data, and endanger test equipment. ($28,000)

o Field Test Laboratory Building Extension- Additional space to the high bay Field Test Lab Building is needed to house required experimental research staff and computer equipment. Currently, such personnel and equipment are located in temporary trailers and remote leased space. ($101,000)

o Storage Shed- Added storage area for support equipment and materials is being proposed. Large items can not be efficiently stored in limited warehouse space due to their bulky mass and temporary ad hoc usage ($118,000)

o Utility Infrastructure- Utility services would be extended to 40 acres of test sites. Existing utility services are nearly fully occupied ($779,000).

o Bulk Storage Facility- This improvement is necessary to properly stow large bulky consumable and reuseable supplies such as 55 gallon drums, palletized bags and gas cylinders. Special requirements for fire protection, electrical grounding and inert gas blankleting necessitates the storage and dispensing of such materials in a separate structure ($86,000).

o Site Clearing- This project is proposed to remove excess soil/rock, equipment, material and temporary supporting items from reassignable experimental sites ($24,000).

o Roadway Lengthening- A road extension would offer secondary access for emergency vehicles to the lower and western portions of the DOE SERI facility site ($103,000).

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY

Solar Energy Research Institute
(B/A in $1000's)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
o General Purpose Equipment	o No Funding	o Acquire the following items; security logger, video tape recorder, milling machine, lathe, vertical and horizontal saws, microcomputers, word processors, data terminals, calibration equipment, crane, dump truck, and automated library system. ($261)
o General Purpose Plant Projects	o No Funding	o Initiate facility enhancements at the SERI site; mesa top road, waste water monitoring station, air effluent monitoring, security improvements, electric power conditioning system, Field Test Lab extension, storage shed, added utility services, bulk storage, site clearing and roadway extension. ($2,071)
TOTAL SOLAR ENERGY RESEARCH INSTITUTE	$0	$2,332

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
ENERGY SUPPLY-PLANT AND CAPITAL EQUIPMENT
SOLAR ENERGY RESEARCH INSTITUTE
GENERAL PLANT PROJECTS

SOLAR ENERGY
(Tabular dollars in thousands. Narrative material in whole dollars.)

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1. Title and location of project: Solar Energy Research Institute
General Plant Projects
Golden, Colorado

2. Project No: 86-

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3. Date A-E work initiated: 1st Quarter FY 1986

3a. Date physical construction starts: 1st Quarter FY 1986

4. Date construction ends: 1st Quarter FY 1987

5. Previous cost estimate: None
Date:

6. Current cost estimate: $2,071,000
Date: 2/84

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7. Financial schedule of construction project funding:

Fiscal Year	Obligations	Costs FY 1986	Costs FY 1987	Costs FY 1988
1986	2,071	1,767	304	0
1987	2,000 1/	0	1,500	500
1988	1,500 1/	0	0	1,000

1 Preliminary FY 1987 and FY 1988 GPP projections

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Solar Energy Research Institute
General Plant Projects
Golden, Colorado

2. Project No: 86-

8. Brief physical description of project:

A. A Mesa Top Access road, two 12-foot lanes with 4-foot shoulders, all-weather (gravel base course, 2 inches of asphalt wearing surface), approximately 5,900 feet long, with associated drainage structures.

B. Two Waste Water Monitoring Stations, consisting of continuous samplers, housed for protection from the elements, provided with electric power service. Two stations are required, one each at the two waste water discharge points from the SERI permanent site.

C. Continuous Air Effluent Monitoring equipment for eight exhaust stack discharges on the Field Test Laboratory Building (FTLB) with appropriate electrical power service and supporting devices.

D. This Security Enhancement Project consist of security access stations at selected entrances of real property improvements (Field Test Laboratory Building and Test Sites); consisting of access card readers, television cameras, associated locks, monitors, and controls, barriers and small interruptable power supplies for security microprocessors. It includes an 8-foot chain link fence with 3-strand barbed wire overhangs encircling the entire SERI properties (encloses 300 acres) with three gates.

E. This Line Conditioning System consists of an isolation transformer, spike suppressor and voltage regulator with secondary electric power distribution lines to be installed in the Field Test Laboratory Building (FTLB).

F. The Field Test Laboratory Building (FTLB) Annex Extension is a 20-foot long, 40-foot wide, two-story addition to the present Butler pre-engineered metal building.

G. This Storage Shed project consists of a 40 x 100-foot metal pre-engineered building on a concrete slab-on-grade foundation with associated electric service (no heating, water, or sewer).

H. This Field Experimental Test Site Utility Infrastructure consists of approximately 4,800 linear feet of water line with a pumping station, 5,800 linear feet of sewer line, 5,000 linear feet of power lines, and 4,800 linear feet of natural gas line.

I. This flammable and non-flammable liquids, gas and chemicals Bulk Storage Facility consists of covered 15 x 20-foot bins with approximate dividers and separations, catch basins, fire protection systems and electrical systems.

CONSTRUCTION PROJECT DATA SHEETS

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1. Title and location of project: Solar Energy Research Institute
General Plant Projects
Golden, Colorado
Project No: 86-

J. The Site Clearing project consists of clearing reassignable field experimental sites, and grading approximately 1-1/4 acres of land to accept new field research activities.

K. The Denver West Parkway Extension project entails extending the Denver West Parkway from station 16+35 to Quaker Street. The project consists of 1,500 cubic yards of earthwork fill and grading, 4-inch base course, 2 inches of asphalt, curbs, gutters, and associated drainage structures and road signs.

9. Purpose, justification of need for and scope of project:

A. This Mesa Top Access Road project will provide safe all-weather access to the mesa top area. This is the primary access route to the mesa top experimental sites. Staff now have to travel to and through Pleasant view on Old Golden Road, turn north on Quaker Street (gravel), and then traverse 1-1/2 miles of unimproved dirt trail. This dirt trail is impassable (even in 4-wheel drive vehicles) during inclement weather. This route would trim a total of 6 miles round trip distance from the Mesa Top to the Field Test Laboratory Building, and provide all-weather access to the mesa top experimental sites by staff and emergency vehicles.

B. The purpose of the Environmental Waste Water Monitoring activity is to accomplish continuous monitoring of waste water effluents to meet permit requirements and regulations under NPDES, RCRA, TSCA and the Safe Drinking Water Act. The effluent monitoring shall provide a basis for evaluating the effectiveness of effluent treatment and control. SERI is required to be in compliance with all effluent limits and environmental commitments as published in environmental assessments and other official documents. This system shall monitor for organic, inorganic, pH, radioactive and heavy metal waste materials. The most severe impact of not providing this facility could be the refusal of the servicing municipal sewer system to accept sewage, therefore, forcing closure of the installation. Not providing this monitoring capability places DOE in continuing non-compliance with EPA record keeping and recording requirements, and places the SERI Operationing Contractor in non-compliance with the prime contract.

C. The purpose of the Air Effluent Monitoring project is to provide the capability to met atmospheric environmental monitoring requirements. Continuous monitoring of all effluent stacks for opacity, SO_2, NO_x, CO_2 and

CONSTRUCTION PROJECT DATA SHEETS

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1. Title and location of project: Solar Energy Research Institute Project No: 86-
General Plant Projects
Golden, Colorado

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other gases/vapors-hydrocarbons is required. SERI has obtained environmental effluent permits for all stacks in use at the Field Test Laboratory Building. These stacks must be monitored continuously to ensure that effluent limits are not exceeded. However, the present facility does not have environmental air effluent monitoring systems. This data is required for quarterly and annual reports to the EPA and DOE. Existing DOE operations shall be upgraded as necessary to meet the requirement of section 1-102 and 1-401 of Executive Order 12088. This project should also be identified on the OMB Circular A-106. Failure to provide for this monitoring capability will not permit SERI to provide monitoring data as required in reports to EPA, DOE, and the the State of Colorado on a quarterly basis. Failure to provide such data could result in ceasing of research activities, and places the Operating Contractor in non-compliance with the prime contract.

D. The purpose of the Security Enhancement Project is to meet operational and physical security requirements of the Institute in an efficient manner. Programmable card-reader access has proven to be an efficient, appropriate method of access control for SERI's dynamic research activity (personnel turnover and change-out of research efforts). The perimeter fence is required to secure the government reservation. At the present time, boundaries are only partially fenced. This fence provides for perimeter security to supplement the current "point security" system. Without this fence, the reservation is open to general, uncontrolled public access up to buildings and field test installations. This project allows SERI to comply with DOE Order 5632, physical protection of government property which may include physical barriers (such as gates and fences) to control or impede access.

E. The purpose of the Line Conditioning System is to provide clean power to various sensitive equipment items. The regional grid (Public Service) power to the FTLB is very unstable, and there are numerous motor loads within the building. Without this project, experiments will continue to obtain erratic data due to line interferences and equipment will continue to be damaged.

F. This 20 x 40-foot, two-story extension project is required to provide technical support space for activities inappropriate to the high-bay, Class 1 laboratory or mechanical room space of the Annex. Such activities include housing of the research staff in attendance of high-bay experiments, professional personnel for analysis and discussion of experiments, and computers for monitoring and interpreting data. Such space requirements are currently met thru the use of temporary trailers and leased space off-site. The trailers are maintenance intensive and energy inefficient. The remoteness of off-site leased facilities introduces inefficiency in supervision, control, coordination, staff time and resources en route back and forth between different locations.

CONSTRUCTION PROJECT DATA SHEETS

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1. Title and location of project: Solar Energy Research Institute
General Plant Projects
Golden, Colorado

2. Project No. 86-

G. This Storage Shed project is to provide storage for items of research and research support equipment and materials. These items, some quite expensive, need to be protected from the elements. They do not, however, require expensive heated warehouse space. The items are large enough to make it impractical to store them in the SERI warehouse. The SERI warehouse space is too valuable for this equipment. As adequate maneuver room for large moving equipment (crane, large forklift) is necessary to store and move these items, access room would waste much valuable space in any other SERI facility. This building would give SERI better inventory control capabilities since all large and valuable items currently not in used could be stored in a common area. This is not available now and as a result, most of this equipment is housed in inadequate and inaccessible storage space or in the labs. The working environment in laboratories and office cubicles would be significantly improved in terms of safety if a satisfactory location to store temporary excess equipment and materials were available.

H. The purpose of the Field Experimental Site Utility Infrastructure is to extend primary utility services to approximately 40 acres of test sites. Areas served by existing services are nearly completely occupied. Developing the next increment of site lands provides flexibility in site selection, and reduces conflicts for available space.

I. The Bulk Storage Facility is required to properly warehouse in terms of environmental, life and fire safety, security, and deterioration; large bulk quantities (55 gallon drums, palletized bags, gas cylinders) of consumable or reuseable supplies. Various research activities require large quantities of materials, such as several heat transfer liquids, charging a solar collector field, and energy storage systems. Other tests may require large quantities of salts, biomass materials, etc. The liquid materials may be interchanged during item testing, or materials stored pending a phase of experimentation. Experiments using large quantities of flammable liquids (methanol, ethanol, hydrocarbons) are planned. This material should be ordered and stored in bulk quantities and dispensed as required. At the present time, SERI has no method to store such materials which provides acceptable environmental safeguards, minimum levels of security protection, acceptable personal safety, and divides/separates to minimize fire losses. The safety aspects of this type of storage and operation makes such a facility mandatory. The necessary special considerations, such as fire protection, grounding, inert gas blanketing, dispensing racks (Class I, Division I, electrical), make it necessary to house and dispense the material from a separate structure. Failure to acquire this facility subjects SERI to continuing potential environmental pollution incidents, personal injury, deterioration of materials, and fire or vandalism dollar losses.

J. The purpose of this Site Clearing project is to remove equipment, materials and supporting temporary features from reassignable experimental sites, and to remove excess stockpiles of soils/rocks adjacent to the field experimental test area and neighboring locations.

CONSTRUCTION PROJECT DATA SHEETS

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1. Title and location of project: Solar Energy Research Institute
General Plant Projects
Golden, Colorado

2. Project No. 86-

K. The Denver West Parkway extension is to provide a secondary access to the lower and western portions of the field experiment test area for emergency vehicles; and to the entire SERI complex, if the Camp George West route is closed for some reason.

10. Details of construction project cost estimates ($1000's)

A. Mesa Top Access:

(1) Engineering (EDIA)	20
(2) Construction:	289
(3) Contingency:	60
(4) Total	369

B. Environmental Waste Water Monitoring Station:

(1) Engineering (EDIA)	7
(2) Construction:	52
(3) Contingency:	11
(4) Total	70

C. Environmental Air Effluent Monitoring Station:

(1) Engineering (EDIA):	6
(2) Construction:	32
(3) Contingency:	8
(4) Total	46

D. Security Enhancement and Fencing Project:

(1) Engineering (EDIA):	16
(2) Construction:	276
(3) Contingency:	55
(4) Total	347

CONSTRUCTION PROJECT DATA SHEETS

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1. Title and location of project: Solar Energy Research Institute
General Plant Projects
Golden, Colorado

2. Project No. 86-

E. Line Conditioning System:

(1) Engineering (EDIA):	2
(2) Construction:	22
(3) Contingency:	4
(4) Total	28

F. Field Test Laboratory Building (FTLB) Annex Expansion:

(1) Engineering (EDIA)	4
(2) Construction:	80
(3) Contingency:	17
(4) Total	101

G. Storage Shed:

(1) Engineering (EDIA):	9
(2) Construction:	89
(3) Contingency:	20
(4) Total	118

H. Field Experimental Utility Infrastructure:

(1) Engineering (EDIA):	59
(2) Construction:	590
(3) Contingency:	130
(4) Total	779

CONSTRUCTION PROJECT DATA SHEETS

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1. Title and location of project: Solar Energy Research Institute
General Plant Projects
Golden, Colorado

2. Project No. 86-

I. Bulk Storage Facility:

(1) Engineering (EDIA):	4
(2) Construction:	68
(3) Contingency:	14
(4) Total	86

J. Clearing Experimental Sites:

(1) Engineering (EDIA):	1
(2) Construction:	19
(3) Contingency:	4
(4) Total	24

K. Denver West Parkway Extension:

(1) Engineering (EDIA):	13
(2) Construction:	75
(3) Contingency:	15
(4) Total	103

11. Method of Performance:

Design and inspection services will be accomplished by negotiated fixed price contract(s) with an architect-engineering firm; in addition to using Operating Contractor and Government employees. Construction procurement will be by fixed price subcontracts awarded on the basis of competitive bids.

CONSTRUCTION PROJECT DATA SHEETS

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1. Title and location of project: Solar Energy Research Institute
General Plant Projects
Golden, Colorado

2. Project No. 86-

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12. Schedule of Project and Other Related Funding Requirements:

	Prior Years	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	Total
A. Total Project Funding							
1. Total Facility Costs							
a. Construction Line item.............	$ 0	$1,767	$1,804	$1,500	$2,100	$1,700	$8,871
b. PE&D.............................	0	0	0	0	0	0	0
c. Expense funded equipment...........	0	0	0	0	0	0	0
d. Inventories.......................	0	0	0	0	0	0	0
Total Facility Costs..................	$ 0	$1,767	$1,804	$1,500	$2,100	$1,700	$8,871
2. Other Project Funding							
a. R&D necessary to complete construction......................	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
b. Other project related costs.......	0	0	0	0	0	0	0
Total Other Project Funding..........	0	0	0	0	0	0	0
Total Project Funding.....................	$ 0	$1,767	$1,804 2/	$1,500 3/	$2,100 4/	$1,700 4/	$8,871

2/ Includes $1,500,000 FY 1987 GPP
3/ Includes $500,000 FY 1987 and $1,000,000 FY 1988 GPP
4/ Includes FY 1988, FY 1989 and FY 1990 GPP preliminary projections.

Solar Program Support $1,300,000

The FY 1986 request for Program Support is $1,300,000, a $300,000 increase from the 1985 appropriation.

The aim of this budget element is to provide cross-technology analytical and administrative support to the overall solar/renewable energy research effort.

FY 1986 funding is necessary to continue contracted support services. Such technical and administrative assistance is required to complement Federal staff abilities and skills. Fixed operating charges for telecommunication/automated office equipment usage will also be funded to promote management efficiencies.

The requested budget will fund anticipated planning and evaluation activities which are essential for supporting the overall FY 1986 Solar/Renewable Energy Program. Future research paths will be developed from these assessments of technical opportunities and probable energy market requirements. Contractor assistance is required to help investigate changing technical and financial needs of the emerging renewable energy industry, support the organization of technology diffusion efforts, and aid in implementing expected new international cooperative research.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY

Program Support
(B/A in $1000's)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
o Program Support	o Crosscutting solar/renewable energy planning and analyses, in addition to telecommunications/automated office system expenses are funded. ($1,000)	o With regard to the overall FY 1986 budget, program thrusts, and ever changing energy supply and demand circumstances; program planning and evaluation shall be conducted to satisfactorily implement and update multiyear technology R&D strategies. Required telecommunication and automated office services will be acquired. Also technology conveyance and international cooperation support activities are anticipated. ($1,300)

Resource Assessment $1,000,000

Resource Assessment is a new FY 1986 proposed budget item. Both the industrial and research communities have identified this activity as a gap in the present DOE Solar Energy Program. In response to industry advice, the House Science and Technology Committee recommended in 1984 that DOE institute a generic solar resource assessment program. This separate budget line item would be in lieu of the recent Department practice which funded only very limited resource assessment activities within individual Solar Energy technologies. Information regarding the distribution, spectral and temporal variability of solar energy resources is critical for designing appropriate new experiments and systems, interpolating laboratory and field results, in addition to optimally siting future energy conversion facilities. Planned activities include data collection, improved measurements technology, data reduction, modelling and algorithm development. The data to be collected varies with geographical location and time of day and year. This information has various components that must be independently measured since they are useful for different solar energy technologies, as for example; total insolation for flat plate collectors, direct insolation for concentrator collectors (scattered radiation does not contribute to concentrator conversion), insolation spectral content for biomass and photovoltaic needs, also wind direction and height above ground for wind machines.

Proposed for FY 1986 are resource measurement and modelling, algorithm development, and research on new measurement techniques. Also prior resource data will be reviewed for its quality and usefulness. Projects will be jointly selected by DOE Solar Energy managers, and representatives from other Federal Agencies, universities and industry ($950,000).

Capital equipment funds are also requested for obtaining data acquisition and processing devices ($50,000).

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY

Resource Assessment
(B/A in $1000's)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
o Reource Assessments	o No Funding	o Plan to conduct analyses of solar energy resources such as insolation and wind in terms of their distribution, spectral and temporal variability. Shall improve the solar radiation data base; develop and evaluate predictive models and algorithms; also, assess data instrumentation and processing methods. ($950)
o Capital Equipment	o No Funding	o Purchase necessary data acquisition/ processing devices. ($50)
TOTAL RESOURCE ASSESSMENT	$0	$1,000

Solar Program Direction $4,900,000

The FY 1986 budget request for Solar Energy Program Direction will support a Full-Time Equivalent (FTE) staffing level of 88. This proposal represents a 1 FTE increase from FY 1985.

The Federal Solar Energy staff activities primarily consist of four major functions; project/task management, research and development coordination, technology diffusion, and general administration duties. A wide variety of professional and clerical skills are necessary to administer six solar energy R&D component technologies, an alcohol fuels loan guaranty effort, and cross-cutting functional activities.

Proposed staffing will manage FY 1986 Solar Energy research funds totalling $143 million, and a significant portion of unfinished prior year initiated activities. In addition, the Alcohol Fuels Financial Incentive group shall evaluate loan guaranty applications, and closely monitor the expenditure of funds secured by granted agreements.

The DOE Solar Energy Program is concerned not only with research and development, but it also serves as a focal point for resolving problems of the fledgling solar/renewable energy industry. In addition to technical program administration, adequate staffing is also needed for devoting time to such issues as energy tax expenditures, the future role of utilities, technology dissemination, international cooperation, and worldwide market development of United States renewable energy goods and services.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY

Solar Program Direction
(B/A in $1000's)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
o Program Direction (Staffing)	o Support a staff of 87 full-time equivalents (FTE's). ($4,766)	o Provides funding for 88 revalved staff-years. ($4,900)

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

PROGRAM OVERVIEW

GEOTHERMAL

The goal of the Geothermal Program is to help build a technology base that will enable the private sector to economically develop the various forms of geothermal resources. The program includes a balance between longer-term research and development, and the more targeted development of technologies that serve to assist industry in meeting critical technical objectives. Many of these research and development activities are designed to reduce the technical and economic barriers restricting the widespread use of geothermal resources by the private sector in the near-term.

Prior Year Accomplishments:

- Completed the 50 MW Binary Demonstration project at Heber, California, and began experimental testing of the entire system.
- Completed the direct heat system at an Auburn, New York school complex.
- Continued long term production testing and modification of specifically designed geopressured wells in the Texas and Louisiana area; acquired lease rights to one ultra-deep geopressured well; and began installation of power generation test equipment at one of the existing design wells in order to conduct conversion experiments. The latter project is being cost-shared with EPRI.
- Established Hot Dry Rock (HDR) flow circulation with the new fracture system; conducted tracer experiments to determine circulation patterns; and carried out short circulation test within the HDR reservoir.
- Completed the research and prepared for field-testing of the high-energy gas fracturing well-stimulation technique, and carried out injection tracer tests and modeling of fluid migration to study brine injection behavior at a new site.
- Completed initial modeling of Los Azufres and Broadlands reservoirs in Mexico and New Zealand, respectively, to verify models for application to U.S. reservoirs; and field-tested numerous fracture mapping and reservoir engineering techniques.

- Drilled slim research boreholes in the Cascades, measured heat flow, compared geology and geophysics results with those predicted by surface surveys, and modeled the structure; drilled the Salton Sea scientific borehole in a hot hydrothermal reservoir near a magma body; and initiated engineering evaluations and resource studies related to the hot scientific borehole.

- Conducted two-phase expansion tests in nozzles for application to second generation binary systems.

- Operated the Geothermal Test Facility (GTF) in the Imperial Valley of California.

- Tested advanced materials in the laboratory and field, and supported tests of industry material and equipment.

- Completed laboratory measurements and analysis of rock penetration mechanics, field-tested a new high temperature borehole mapper, and laboratory-tested new downhole instrumentation.

- Initiated development of prototype non-conventional drilling equipment, field-tested new fluid loss control materials, and cost-shared DOE-Industry cooperative advanced drilling proof-of-concept tests.

- Selected Coso, California and Long Valley, California as final candidate sites for magma studies; tested selected materials for magma compatibility, and completed preliminary analysis of extraction concepts and magma system economics.

- Conducted cooperative geothermal technical assistance activities in eleven states in order to evaluate key geothermal prospects not yet developed by the private sector.

- Developed a formal technology transfer plan, and performed numerous technical assistance and technology transfer activities, including program reviews, seminars, conferences, and workshops.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
GEOTHERMAL
ENERGY SUPPLY RESEARCH AND DEVELOPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

Geothermal (CE)	FY 1984 Appropriation	FY 1985 Appropriation	FY 1986 Base	FY 1986 Request
Hydrothermal Industrialization				
Operating Expenses	$ 1,868	$ 990	$ 990	$ 0
Capital Equipment	$ 0	$ 0	$ 0	$ 0
Subtotal	$ 1,868	$ 990	$ 990	$ 0
Geopressured Resources				
Operating Expenses	$ 5,000	$ 5,400	$ 5,400	$ 3,600
Capital Equipment	$ 0	$ 0	$ 0	$ 0
Subtotal	$ 5,000	$ 5,400	$ 5,400	$ 3,600
Geothermal Technology Development				
Hot Dry Rock Research				
Operating Expenses	$ 7,540	$ 7,500	$ 7,500	$ 5,500
Capital Equipment	$ 0	$ 0	$ 0	$ 0
Subtotal	$ 7,540	$ 7,500	$ 7,500	$ 5,500
Hydrothermal Research				
Operating Expenses	$ 11,277	$ 9,729	$ 9,729	$ 8,000
Capital Equipment	$ 0	$ 200	$ 200	$ 200
Subtotal	$ 11,277	$ 9,929	$ 9,929	$ 8,200
Hard Rock Penetration Research				
Operating Expenses	$ 2,640	$ 4,400	$ 4,400	$ 2,400
Capital Equipment	$ 0	$ 200	200	$ 200
Subtotal	$ 2,640	$ 4,600	$ 4,600	$ 2,600
Magma Energy Extraction Research				
Operating Expenses	$ 845	$ 1,400	$ 1,400	$ 4,400
Capital Equipment	$ 0	$ 0	$ 0	$ 100
Subtotal	$ 845	$ 1,400	$ 1,400	$ 4,500

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
GEOTHERMAL
ENERGY SUPPLY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars)

Geothermal	FY 1984 Appropriation	FY 1985 Appropriation	FY 1986 Base	FY 1986 Request
Geothermal Technology Transfer				
Operating Expenses	$ 100	$ 1,000	$ 1,000	$ 0
Capital Equipment	$ 0	$ 0	$ 0	0
Subtotal	$ 100	$ 1,000	$ 1,000	0
Total Geothermal Technology Development	$22,402	$24,429	$ 24,429	$20,800
Program Direction	$ 1,000	$ 1,025	$ 1,025	$ 800
Grand Total				
Operating Expenses	$30,270	$31,444	$31,444	$24,700
Capital Equipment	$ 0	$ 400	$ 400	500
	$30,270 A/	$31,844 B/ C/	$31,844	$25,200 C/
Staffing				
Total FTE	14	15	15	15

A/ Reduced by $189,000 Small Business Innovative Research (SBIR) Allocation

B/ Reflects savings of $168,000 for section 2901 of the Deficit Reduction Act of 1984 (P.L. 98-369)

C/ The FY 1985 amount does not reflect a reduction of $2,037,000 and $1,200,000 in FY 1986 for IG Audits/prior year deobligation Management Initiative Savings

Authorization: P.L. 93-410 Geothermal Energy Research, Development and Demonstration Act of 1974.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
ENERGY SUPPLY RESEARCH AND DEVELOPMENT

(In thousands of dollars)

GEOTHERMAL

FY 1985 Conference Mark	$ 32,087
Less ADP Reduction	-$ 75
Less Proposed Rescission	-$ 168
FY 1985 Adjusted	$ 31,844
Built in Increases and Decreases:	$ 0
FY 1986 Base	$ 31,844
Program increases and decreases:	
Hydrothermal Industrialization	
o Eliminate state technical assistance activities	-$ 990
Geopressured Resources	
o Decrease design well operations	-$ 1,800
Hot Dry Rock	
o Reduce technology base activities in support of the project	-$ 2,000
Hydrothermal Research	
o Eliminate funds for permeability enhancement	-$ 1,000
o Reduce activities related to the Salton Sea Scientific Drilling Project, heat cycle, materials and support of GTF	-$ 1,640
o Increase funding for brine injection technology and caldera reservoir investigations	+$ 911
Hard Rock Penetration Research	
o Eliminate funding for drilling instrumentation and the DOE/Industry cost-shared drilling project	-$ 1,800
o Decrease funding for non-conventional drilling techniques, and fluid loss control	-$ 400
o Increase funding for mechanics of rock penetration	+$ 200
Magma Energy Extraction	
o Increase funding for geoscience investigations, and equipment and materials research	+$ 3,000
Technology Transfer	
o Eliminate funds for technology transfer activities	-$ 1,000
Program Direction	
o Reprice staffing and 5% pay cut	-$ 225
Capital Equipment	
o Include funds for magma energy extraction equipment	+$ 100
FY 1986 Budget Request	$ 25,200

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

GEOTHERMAL ENERGY NARRATIVE

Geothermal.. $25,200,000

The FY 1986 President's Request for Geothermal is $25,200,000. This represents a decrease of $6,644,000 from the FY 1985 Appropriation. The major subprograms in the FY 1986 Budget Request are: Geopressured Resources, Geothermal Technology Development, and Program Direction.

The FY 1986 President's Request includes an increased emphasis on projects which are being cost-shared with industry. In the geopressured resources area, cost-shared geopressured-geothermal applications research is planned involving electric power generation and direct heat applications. In the geothermal technology development area, there are also foreign country and U.S. industry cost-shared projects. One involves the drilling of deep heat flow holes to develop and test exploration tools for potential reservoirs in the Cascades. In addition, there are a number of other areas where cost-sharing is anticipated. These areas are addressed in the appropriate narrative sections.

Hydrothermal Industrialization............................. $ 0

No additional FY 1986 funds are being requested. The assessment of hydrothermal energy resources on a state basis has progressed to a stage where individual states have the capability to continue these activities as required.

Geopressured Resources..................................... $ 3,600,000

The objective of the geopressured resource program is to define the energy and heat content of the geopressured resource; to conduct careful scientific experiments with geopressured reservoirs to determine their hydrodynamic characteristics, the source of the drive mechanism, and the origin of the contained chemical species; and to determine the technical and economic feasibility of extracting and using chemical, thermal, and mechanical energies associated with geopressured brines. The behavior of gepressured reservoirs under extended tests is the critical remaining research question, and the completion of flow experiments (for which the existing research facilities are uniquely designed) is important for later energy investment decisions by industry.

As a result of earlier research activities in this area, the location and general characteristics of geopressured aquifers on the Texas - Louisiana Gulf Coast have been identified. Methane and thermal energy extraction experiments have been performed, and the technology is being improved as knowledge of the geopressure regime is enhanced. Research questions also remain in the environmental area of surface subsidence and seismicity.

Activities being undertaken in FY 1986 are planned to address the uncertainties in reservoir hydrodynamics and environmental effects.

In FY 1986, flow dynamics, geochemical behavior, and parameter variability data from past test will be analyzed in support of modeling the hydrodynamics characteristics of the system: reservoir, overlying shale beds, possible gas caps, dissolved and dispersed gas, production zones, and reinjection areas. The existing design wells will be used to carry out experiments involving variable flow rates, with and without scaling inhibition chemicals, and pressure buildup tests to seek data on the areal extent of various sandstone strata and the possible location of confining or leaking faults. Total energy recovery will be evaluated in a joint experimental program with the Electric Power Research Institute (EPRI). Initially, chemical and thermal energy components will be tested in combination. Later, hydraulic energy recovery will be combined, and the total system analyzed and tested experimentally.

Geothermal Technology Development............................ $20,800,000

There are four geothermal technology development activities included under the FY 1986 President's Request: hot dry rock research, hydrothermal research, hard rock penetration research, and magma energy extraction research.

- o Hot Dry Rock Research................................ $5,500,000

  The objective of Hot Dry Rock (HDR) research is to study the fundamental properties of deep hot crystalline rock systems and, based on those scientific findings, determine the technical and economic feasibility of extracting geothermal heat from hot dry rock resources. Proof-of-concept experiments have been conducted with a single-fracture thermal loop at Fenton Hill, New Mexico, and field experiments have proven the energy extraction concept of connecting two wells in hot dry rock with a manmade fracture system. While the concept appears valid at modest power levels for short periods, there is no assurance HDR reservoirs can be made large enough and of sufficient duration to attract private sector development. To answer these questions, an HDR thermal loop is being constructed at Fenton Hill. The preparation and testing of this loop is covered by an International Energy Agency cooperative agreement, and both West Germany and Japan have made important financial and scientific contributions to the project. Their support has been one of the major factors in the experimental progress to date.

  FY 1986 funds will be used to complete the HDR thermal loop. The final thermal loop has an estimated energy extraction level of 20-30 MWt; extensive testing will be conducted to answer questions on HDR feasibility regarding (1) flow control through a multi-fractured system; (2) thermal drawdown and reservoir longevity; (3) fracture mapping; (4) reservoir hydrodynamics; (5) changes in system flow impedance; (6) rock-fluid interactions; and (7) environmental effects.

o Hydrothermal Research $8,000,000

The objective of the hydrothermal research activity is to expand the economically exploitable hydrothermal resource base available for private sector development by conducting research and development directed in particular toward second generation binary systems that will utilize widespread moderate temperature hydrothermal resources. Royalties from power generated on Federal land already exceed the funding level for DOE hydrothermal research, and those Government revenues will increase greatly as the advancing technology base provides industry with the economic opportunity to exploit more of the resource. Research and development will be conducted in the following areas: geophysical and other scientific studies to reduce the cost of exploration, reservoir assessment, and field development; scientific and technological advances to reduce the capital costs of electric generating facilities; and fundamental understanding of the structure, physics and chemistry of geothermal reservoirs to reduce the technical risk of reservoir or fluid handling system failures.

In FY 1986, funds will be used to continue research associated with brine injection technology, reservoir definition technology, heat cycle conversion, materials, GTF support, caldera reservoir investigations, and the Salton Sea Drilling Project.

- Brine Injection Technology:($2,400,000) The objective of this task is development of technology for the economic disposal of spent brines by injection into geothermal reservoir formations in order to recharge the reservoir, dispose of the brine, and minimize subsidence.

  Geothermal power plants which generate electricity from liquid-dominated hydrothermal reservoirs produce enormous quantities of spent fluids that must be disposed of in an environmentally acceptable manner. Subsurface disposal of spent brines is required by local environmental regulations. The present inability to reliably predict and mitigate potential problems with subsurface disposal of these fluids has been identified by private industry as a serious technological/economic barrier to widespread geothermal development in the United States. Funds requested in FY 1986 will be used to conduct brine injection research in the following areas:

  Fluid Migration Monitoring and Prediction - development and testing of tracers and geophysical monitoring instrumentation, and the development of modeling techniques to predict the migration of spent brines injected into geothermal reservoirs, whose structure is complicated by fractures and matrix permeability.

  Surface Treatment Technology - development of accurate particle monitoring devices, particle control technology, and chemical conditioning methods to prevent adverse chemical reactions in the well and adjacent injection zones.

  Well Completion Technology - development of advanced well completion techniques to prevent permeability degradation in the near wellbore region; to prevent casing/cement failures; and to extend the useful life of injection wells. Industry cost-sharing is anticipated in these research areas.

- Reservoir Definition Technology: ($1,900,000) The objective of this task is to improve the technologies needed to locate, delineate, characterize, and control hydrothermal reservoirs. Specific areas of research include geothermal formation evaluation and well testing, resource capacity and reservoir modeling, and observations of reservoir production trends and longevity. The FY 1986 request will support research in the following areas:

  Reservoir Productivity Assesment Technology - research, development and testing of hydrothermal reservoir performance and detailed behavior under production conditions, and the comparison of this data with model predictions. To this end, full modeling of geothermal reservoirs in Mexico (Los Azufres) and New Zealand (Broadlands) will be performed for correlation with well field data, thus confirming models and verifying geologic theories of origin.

  Fracture Mapping Technology - research and evaluation of the capability of various surface and subsurface geophysical techniques to locate natural fracture systems within reservoirs with sufficient accuracy that they can be successfully targeted for drilling.

- Heat Cycle Research: ($600,000) The objective of this task is development of technology required for the economic generation of electricity from moderate temperature hydrothermal resources which are four times as numerous as those of the high-temperature resources currently exploitable with first generation energy conversion technology. If these reservoirs are to be exploited economically, a new generation of more efficient, reliable, and less costly binary technology must be developed. FY 1986 funds will be used to perform advanced research in supercritical and two-phase expansion cycles, heat transport properties of secondary fluids, and new heat transfer approaches. The results of this research will lead to improved systems performance and reduced construction and operating costs for second generation binary systems.

- Geothermal Test Facility (GTF): ($200,000) The objective of the test facility task is to provide a field site for testing of geothermal energy conversion components, materials, and systems in an actual geothermal environment. FY 1986 funds will be used for operation of the DOE Geothermal Test Facility near Holtville, CA. The facility includes geothermal wells and brine handling facilities, test pads, workshops. offices, and a chemistry laboratory. This effort will be done on a cost reimbursable basis with the private sector.

- Materials Research: ($400,000) The objective of the materials task is to develop geochemical engineering techniques and materials capable of increasing equipment life and reliability, and reducing the cost of fluid handling. Funds in FY 1986 will be used to develop downhole materials that are cost-effective in the extraction of geothermal fluids, and to advance non-destructive evaluation techniques to predict and prevent failures of drilling components, well completion materials, and energy conversion component materials. Cost-sharing will be sought and can be expected.

- Caldera Reservoir Investigations: ($2,000,000) The objective of this task is to conduct research on techniques for investigating the nature of hydrothermal reservoirs associated with young andesite volcanoes of the Cascade Range in California, Oregon, and Washington. In such areas the geothermal reservoirs are masked by shallower, cooler aquifers and lower vertical permeability so that thermal gradient measurements and other scientific measurements only begin to characterize the reservoirs at greater depths. Geophysical measurements combined with wells designed for maximum scientific return will be made to perform this research.

  FY 1986 funds will be used to provide additional slim research boreholes and carry out research and tests of new system sensing and evaluation techniques to study the hydrogeologic configuration of high temperature aquifers in the young volcanic fields of the Cascades. The results of prior year testing and measuring of several deep thermal gradient research boreholes throughout the Cascades will be analyzed, models of the reservoirs made, and theories of the formation and behavior of the reservoirs will be developed. The project is being cost-shared with industry under cooperative agreements.

- Salton Sea Scientific Drilling Project: ($500,000) The objective is to determine the nature of potential reservoirs that underlie a known high-temperature hydrothermal reservoir, in order to better understand the genesis and structure of hydrothermal resources and to assess theories that the nation's hydrothermal resources are far larger than previously estimated.

The FY 1986 funds will be used to complete engineering, chemical analyses, instrument testing, and resource studies related to the scientific drilling, testing and measuring in deep, hot reservoirs containing highly corrosive but potentially valuable brines. The results of this research will be synthesized and modeled to give new understanding of the geothermal system characteristics.

o Hard Rock Penetration Research......................	$2,400,000

Although geothermal wells are drilled and completed using technology adapted and evolved from oil and gas well drilling, the hot, hard crystalline rock and corrosive environment causes such a rapid degradation of the drilling equipment that geothermal wells cost up to four times the cost of similar oil and gas wells. The suppliers of drilling equipment have no market incentive to fund research to improve these costs, because the industry drills about one thousand oil and gas wells for each single geothermal well drilled. Since the cost of geothermal field development is at present roughly half the total cost of a geothermal power installation, the program emphasizes research into new concepts that show promise for incorporation into a second generation geothermal drilling system that will reduce the cost of drilling and completing geothermal wells. Promising technical areas include advanced alloys, new physical processes and new design concepts.

In FY 1986, research tasks will continue in the following areas:

- Mechanics of Rock Penetration: ($ 900,000) The objective of this task is to measure the parameters associated with rock penetration by crushing, spalling, shearing, erosion, and shock loading under simulated geothermal downwell conditions.

  In FY 1986, test equipment will be fabricated and tested over a selected range of conditions in a geothermal rock mechanics laboratory. Several tests of rock/cutter interactions will be conducted to test conditions and rock types leading to design improvements that will reduce costs.

- Borehole Mapping: ($500,000) The objective of this task is to develop techniques and instrumentation for characterizing geothermal wellbores and improving mapping accuracies.

  Funds requested in FY 1986 will be used to devise improved techniques and to design prototype equipment for mapping both the condition and location of geothermal wellbores. In addition, wellbore fracture mapping tools will be developed, and new lost circulation techniques explored.

- Non-conventional Drilling Techniques: ($400,000) The objective of this task is to evaluate, design, and test selected advanced candidate methods for breaking and removal of rock, and which have the potential for development into an advanced drilling system that could lead to a 25-50% geothermal well cost reduction.

  FY 1986 activities will include the design and fabrication of research equipment to test unconventional drilling techniques such as those using water jets, downhole motors, plasmajets, diesel fuel flame-jets, drilling with continuous tubing and other unique methods.

- Drilling Fluid Loss Control: ($600,000) The objective of this task is to develop new effective materials for controlling the loss of drilling fluids into fractures or aquifers encountered during drilling and completion in high temperature environments. The research includes seeking a substance that will degrade after it has performed its intended function, thus avoiding formation damage.

  FY 1986 funds will be used for the development of new fluid loss control materials which will be additives to drilling fluids containing bentonite, sepiolite or attapulogite. Once the materials are developed, they will be tested in the Fluid Loss Control Test Facility to determine their behavior under a range of downwell conditions, and eventually be tested in the field.

o Magma Energy Extraction.............................. $4,400,000

The objective of this activity is to identify a potentially accessible magma reservoir and perform research on the technical and economic feasibility of extracting heat from molten rock. The U.S. Geological Survey has estimated that the size of the molten and near-molten rock resources within the top 10 kilometers (6.2 miles) of the earth's surface is between 50,000 and 500,000 quadrillion BTU (quads) in terms of available heat energy. Previous activities involved identifying, characterizing, and ranking candidate magma reservoir prospects.

The FY 1986 funds will be used to conduct research and geophysical measurements at selected candidate sites to test techniques for detecting the location and apparent size of magma bodies, the drilling of deep thermal gradient holes in which new sensing techniques will be evaluated, and to identify the final preferred test site. Activities will also include research on extremely high temperature heat-exchanger and heat extraction equipment, and the design of experimental drilling equipment, and testing of components designed of selected materials, for use in the above 1000°C environment to be encountered in molten magma.

o Program Direction.................................... $ 800,000

The budget request supports 15 FTEs. This includes administrative and technical personnel who manage a broad range of geothermal R&D activities. Personnel assigned to Headquarters will perform a number of responsibilities including the establishment of broad objectives, determination of work scopes, allocation of general resources, and technical management necessary for program direction. Responsibilities include the assessment of progress made in meeting DOE technical milestones and cost budgets, coordination of contractor activities, and initiation of appropriate actions to resolve problems in any of these areas. Further, responsibilities will include administrative and functional activities such as budgeting, procurement, long and short range program planning and personnel management activities. In addition, some personnel will be required to interface with a number of other Federal agencies (such as DOD, NASA, NBS, and DOI), national laboratories, industrial concerns, and international bodies in order to execute program activities.

In addition to new activities proposed for FY 1986, additional research and industrialization projects which were initiated in prior years will be completed during this same time interval.

Capital Equipment.. $ 500,000 *

Capital equipment funds will be used for the acquisition of laboratory apparatus and equipment necessary to support research in the hydrothermal, hard rock penetration, and magma energy extraction research areas.

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* Budgeted within the Geothermal Technology Development program element.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Geothermal Energy

(BA in $1000)

Key Activity	Estimated Activities During FY 1985	Planned Activities for FY 1986
Hydrothermal Industrialization	o Continue to manage and monitor prior year funded activities related to the following projects: - 50 MWe binary plant at Heber, California. - Geothermal hybrid powerplant near Susanville, California. - Direct heat applications. ($ 0)	o Continue to monitor and manage prior year funded activities associated with the Heber and direct heat projects. ($ 0)
	o Perform state technical assistance activities aimed at identifying key geothermal prospects not yet developed by the private sector. ($ 990)	o No new activities are planned for FY 1986. ($ 0)
Geopressured Resources	o Conduct flow testing and support activities for specifically designed geopressured production wells in the Texas and Louisiana area. Begin electric power conversion program in cooperation with EPRI. ($5,400)	o Continue flow testing and support activities for the geopressured production design wells. Analyze production and geochemical data from tests. Conduct electric power conversion test in cooperation with EPRI. ($3,600)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Geothermal Energy

(BA in $1000)

Key Activity	Estimated Activities During FY 1985	Planned Activities for FY 1986
Geothermal Technology Development	HOT DRY ROCK RESEARCH o Complete circulation loop. Flow test interim system, and initiate installations for the complete heat extraction system. Continue scientific and engineering support. ($7,500)	HOT DRY ROCK RESEARCH o Complete engineering development and construction of the HDR thermal loop. ($5,500)
	HYDROTHERMAL RESEARCH Brine Injection Technology o Conduct research related to fluid migration monitoring and prediction, surface treatment technology, and well completion technology ($2,074)	HYDROTHERMAL RESEARCH Brine Injection Technology o Continue research in the areas of fluid migration monitoring and prediction, surface treatment technology, and well completion technology. ($2,400)
	Reservoir Definition o Perform research in the areas of reservoir productivitiy assessment and fracture	Reservoir Definition o Continue research related to productivity assessment

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Geothermal Energy

(BA in $1000)

Key Activity	Estimated Activities During FY 1985	Planned Activities for FY 1986
Geothermal Tech Development (Cont'd)	mapping techniques, including field testing of fracture mapping techniques. ($1,900)	and field-testing of new fracture mapping techniques. Model geothermal reservoirs for correlation with well field data to confirm models and verify geologic theories of origin. ($1,900)
	Heat Cycle Research o Conduct research in advanced heat cycles using new working fluid mixtures at supercritical conditions, new heat transfer approaches and extended life of downhole pumps. ($1,300)	Heat Cycle Research o Continue research in advanced heat cycles using new working fluids mixtures, and new heat transfer approaches. ($ 600)
	Permeability Enhancement o Develop a computer model of a high-energy gas fracture well stimulation concept; evaluate high temperature propellants for high-energy gas generation, and lab-test the techniques. ($1,000)	Permeability Enhancement o No new activities planned for FY 1986. ($ 0)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Geothermal Energy

(BA in $1000)

Key Activity	Estimated Activities During FY 1985	Planned Activities for FY 1986
Geothermal Tech Development (Cont'd)	Materials Research	Materials Research
	o Develop downhole materials that are cost-effective in the extraction of geothermal fluids, and perform non-destructive evaluation techniques to perdict and prevent failures of drilling components, well completion materials, and energy conversion component materials. ($ 700)	o Continue materials research related to developing geochemical engineering techniques and materials for increasing equipment life and reliability. ($ 400)
	Salton Sea Scientific Drilling Project	Salton Sea Scientific Drilling Project
	o Study and analyze the geophysical, engineering, chemical and related data obtained from the very hot scientific hydrothermal well. ($1,000)	o Complete engineering, chemical analyses, instrument testing and resource studies related to the hot scientific hydrothermal well, and synthesize results of all the scientific research and modeling related to the well. ($ 500)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Geothermal Energy

(BA in $1000)

Key Activity	Estimated Activities During FY 1985	Planned Activities for FY 1986
Geothermal Tech-Development (Cont'd)	Caldera Reservoir Investigations o Initiate tests of new system sensing and evaluation techniques to study the hydrogeologic configuration of high temperature acquifers in the young volcanic fields of the. Cascades. ($1,425)	Caldera Reservoir Investigations o Continue to carry out tests of new system sensing and evaluation techniques to study the hydrogeologic configuration of high temperature aquifers in the young volcanic fields of the Cascades. Analyze, model, and develop theories of formation and behavior of reservoirs in the Cascades. ($2,000)
	Geothermal Test Facility o Operate the DOE Geothermal Test Facility at East Mesa, California, and provide support for test operations conducted by national laboratories, contractors, and outside experimenters. ($ 330)	Geothermal Test Facility o Continue to operate the DOE Geothermal Test Facility but on a cost reimbursable basis with the private sector. ($ 200)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Geothermal Energy

(BA in $1000)

Key Activity	Estimated Activities During FY 1985	Planned Activities for FY 1986
Geothermal Tech-Development (Cont'd)	HARD ROCK PENETRATION RESEARCH	HARD ROCK PENETRATION RESEARCH
	Mechanics of Rock Penetration o Conduct laboratory measurements of rock parameters, and correlate predictions of downhole conditions with empirical data. ($ 700)	Mechanics of Rock Penetration o Fabricate and test equipment in a rock mechanics laboratory over a selected range of conditions, and conduct tests of rock/cutter interactions ($ 900)
	Borehole Mapping o Develop designs for wellbore fracture mapping tools and to enhance techniques for mapping lost circulation zones; and assemble laboratory test prototype units. ($ 500)	Borehole Mapping o Devise improved techniques and design prototype equipment for mapping both the condition and location of geothermal wellbores. ($ 500)
	Drilling Instrumentation o Devise instruments to measure critical downwell drilling parameters, and design and test data conditioning, recording, and transmitting equipment for use on turbodrills and conventional drills. ($ 800)	Drilling Instrumentation o No new activities planned for FY 1986. ($ 0)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Geothermal Energy

(BA in $1000)

Key Activity	Estimated Activities During FY 1985	Planned Activities for FY 1986
Geothermal Tech Development (Cont'd)	HARD ROCK PENETRATION RESEARCH	HARD ROCK PENETRATION RESEARCH
	Non-conventional Drilling	Non-conventional Drilling
	o Continue feasibility studies of advanced drilling concepts;, develop a flame jet drilling technique that uses thermal spallation as a means of penetrating rock for deep holes.	o Design and fabricate research equipment to test unconventional drilling techniques, such as those using water jets, downhole motors, plasmajets, diesel fuel flame jets, and drilling with continuous tubing.
	($ 700)	($ 400)
	Fluid Loss Control	Fluid Loss Control
	o Continue to select and screen materials to be used for lost circulation control during drilling, and perform laboratory experiments to determine their behavior under a range of downwell conditions.	o Develop and test new fluid loss control materials which will be additives to drilling fluids containing bentonite, sepiolite, or attapulgite.
	($ 700)	($ 600)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Geothermal Energy

(BA in $1000)

Key Activity	Estimated Activities During FY 1985	Planned Activities for FY 1986
Geothermal Tech-Development	HARD ROCK PENETRATION RESEARCH	HARD ROCK PENETRATION RESEARCH
	DOE-Industry Cost Shared Drilling	DOE-Industry Cost Shared Drilling
	o Work with an industrial panel to select and define a prototype advanced drilling system that incorporates all available improvements, and cost-share with industry the development, fabrication, and field test of the prototype. ($1,000)	o No new activities are planned in FY 1986. ($ 0)
	MAGMA ENERGY EXTRACTION	MAGMA ENERGY EXTRACTION
	o Develop preliminary characterizations of candidate magma reservoirs identified in previous years; develop designs for magma energy extraction equipment, and determine the principal requirements for materials suitable to use in a magma environment. ($1,400)	o Conduct research and geophysical measurements at selected sites; continue to design experimental equipment and to conduct research on extremely high temperature heat-exchanger and heat extraction equipment; and test selected materials for use in a magma environment. ($4,400)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Geothermal Energy

(BA in $1000)

Key Activity	Estimated Activities During FY 1985	Planned Activities for FY 1986
Geothermal Tech Development	TECHNOLOGY TRANSFER o Transmit agency sponsored R&D results to scientists, engineers, educators, and other decision makers thru various methods, such as topical meetings, program reviews with industry, seminars, and publications. ($1,000)	TECHNOLOGY TRANSFER o No new activities planned in FY 1986. ($ 0)
PROGRAM DIRECTION	o Supports a staff of 15 FTE's to manage a broad range of Geothermal R&D activities. ($1,025)	o Supports a staff of 15 FTE's to manage a broad range of Geothermal R&D activities. Change in funding from FY 1985 represents a repricing of FTEs. ($ 800)
CAPITAL EQUIPMENT	o Laboratory apparatus and equipment in support of research in the areas of hydrothermal and hard rock penetration. ($ 400)	o Laboratory apparatus and equipment in support of research in the areas of hydrothermal, hard rock penetration, and magma energy extraction. ($ 500)
Total Geothermal	$31,844	$25,200

DEPARTMENT OF ENERGY

Proposed Appropriation Language

Energy Conservation

For necessary expenses in carrying out energy conservation activities, [$467,969,000] $176,130,000 to remain available until expended [: Provided, That for the base State Energy Conservation Program (part D of the Energy Policy and Conservation Act, sections 361 through 366), each State will herein match in cash or in kind not less that 20 percent of the Federal contribution: Provided further, That these funds may be used for grants to the Commonwealth of the Northern Mariana Islands, the Federated States of Micronesia, the Republic of the Marshall Islands, and the Republic of Palau under part D of title III of the Energy Policy and Conservation Act (relating to primary and supplemental State energy conservation programs, 42 U.S.C. 6321-6327) and under the National Energy Extension Service Act (42 U.S.C. 7001-7011): Provided further, That pursuant to section 111(b)(1)(B) of the Energy Reorganization Act of 1974, as amended, 42 U.S.C. 5821(b)(1)(B), of the amount appropriated under this head, $16,000,000 shall be available for a grant for basic industry research facilities located at Northwestern University without section 111(b)(2) of such Act being applicable]. (Department of the Interior and Related Agencies Appropriations Act, 1985, as included in Public Law 98-473.)

DEPARTMENT OF ENERGY
FISCAL YEAR 1986 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF ESTIMATES BY APPROPRIATION BY MAJOR ACTIVITY
ENERGY CONSERVATION
BUDGET AUTHORITY IN THOUSANDS OF DOLLARS

	FY 1984 Actual	FY 1985 Estimate	FY 1986 Request
Transportation	64,658	61,772	42,975
Industrial	33,517	31,925	35,500
Buildings and Community Systems	37,198	41,338	37,300
Multi-Sector	12,722	23,342	26,700
Facilities	---	15,681	---
Subtotal, Conservation R&D	148,095	174,058	142,475
State and Local	280,166	283,149	225,579
Policy and Management	1,280	1,727	2,600
Policy Analysis	750	245	---
Subtotal, Energy Conservation	430,291	459,179	370,654
Appropriated to HHS.	---	---	-190,524
Addback of Proposed Rescission	---	931	---
Use of Prior Year Balances	---	-1,500	---
Saving from Management Initiatives...	---	---	-4,000
Total, Energy Conservation	430,291	458,610	176,130

FY 1986 Congressional Budget
MAJOR ACTIVITY OVERVIEW
Energy Conservation

Energy conservation continues to make significant contributions to the nation's increasing energy and economic efficiency. In recent years, the amount of energy required to produce a constant dollar of gross national product steadily declined--by more than 20 percent since 1973. Total energy consumption in 1983 was actually less than that of ten years earlier, and far below what pre-1973 trends would have otherwise predicted had they continued. Yet economic output over this same period of time continued to expand at an average rate of about 2.5 percent per year. Improvements in energy efficiency alone after 1973 are estimated to account for about 14 quads* of reduced growth in energy demand in 1982, and for about 60 quads of cumulative energy savings over the last 10 years.

Hence, energy conservation may be viewed as a significant energy resource. It plays a prominent role in overall national energy policy and is a critical element of a balanced and diverse energy resource system. Its continued development affords important opportunities for further improvement in energy and economic productivity, and for advancing the nation's competitive position in technology leadership and international trade.

MISSION AND OBJECTIVES

The mission of the Energy Conservation Program is to encourage the full development of energy conservation's potential. Accordingly, the program carries out a broad range of activities, each designed to contribute in a significant way to the technical and economic environment necessary to support this development. These activities focus primarily on basic and applied research, technology development, information, and technology transfer. They also include energy management within the federal establishment, development of guidelines and standards where warranted or otherwise required by law, and implementation of a number of Congressionally mandated programs.

The objectives of these activities are to: (1) improve the efficiency by which resources are used in the economy, focusing on energy; (2) enhance the diversity of available energy end-use technologies, focusing in particular on alternatives to those currently based exclusively on one form of energy; (3) build an effective technology base of fundamental scientific and engineering knowledge from which commercial technology development is derived; and (4) facilitate, through information and related activities the efficient working of energy end-use markets.

Because the focus of energy conservation is on improving the efficiency of energy use, the Conservation Research and Development Program is organized by energy-using sectors of the economy. These include residential and commercial buildings and community systems, transportation, and industry. Energy use in 1983 was distributed about evenly among these three sectors. In addition to these categories, there are many technologically related aspects of energy use which are common to all sectors of the economy. Combustion is one example, and the use of advanced materials in energy-related equipment and high-temperature environments is another. Hence, a fourth element of the Conservation R&D program addresses the cross-cutting aspects of energy conversion and utilization.

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*Quadrillion (10^{15}) British Thermal Units, equivalent to one year's consumption of oil at the rate of 500,000 barrels per day.

In FY 1986, the Energy Conservation Program will carry out activities in the following budget categories:

- o Buildings and Community Systems
- o Industrial Programs
- o Transportation
- o Multi-Sector

Some of the Energy Conservation Program's results demonstrate the constructive role that government can play in energy research and development. Examples include:

Buildings. Basic research on building envelope materials, ventilation, and controls has led to a better understanding of the complex interactions among building components and systems. Computer models of energy use in buildings have been developed and are being used by designers and builders. New homes and commercial buildings built using new designs and improved building materials in accordance with this research consume only one half as much energy as pre-1970 buildings. In the building equipment area, examples of cost-shared research with private scientists and manufacturers include: a nonsooting oil-fired boiler, and power-gas burner (saving 15-20%); heat pump water heater (50% savings); advanced refrigerator/freezer and advanced motor compressor (35 to 50% efficiency improvements); a solid state ballast for fluorescent lighting (20-25% savings); cogeneration for district heating (saving 20-25% and allowing substitution of coal and municipal waste for scarce fuels). Currently budgeted and planned research and development addresses advances in envelope systems and materials such as ventilation, insulation, windows and controls; improved combustion heating equipment, heat pumps, and heat exchangers; more efficient lighting and daylighting; integrated community energy systems; and information and technical transfer activities.

Industry. The industrial energy conservation program seeks to increase energy use efficiency and to promote the substitution of alternative fuels for conventional fuels in the industrial sector via a program of carefully targeted technology research and development activities. Most of the activities are conducted by the private sector and are cost-shared. Over 170 projects have been supported to date. Of these, 23 have been completed, and the rest are in various research phases. The 23 projects completed represent an estimated current annual savings of over 22 trillion Btu's, based on the market penetration to date. These include high temperature ceramic recuperators (500 units operating at temperatures up to 2600°F); high effectiveness recuperators (40 units operating); foam-for-water systems for textile finishing (now used in processing over 12 billion yards of fabric annually); the first U.S. slow speed diesel cogeneration system (one system operating and saving 1.5 trillion Btu's, with four additional systems being negotiated without Federal involvement); Energy Analysis and Diagnostic Centers at 12 universities (272 audits to date to assist small and medium size firms to conserve energy); fumes-as-fuel in precoated metals (30 units in operation saving up to 85% of the fuel previously consumed); and an improved slot forge furnace (27 units operating). Current program activities include thin strip casting of steel, realtime metallurgical analysis of molten steel, coal-fired Brayton cogeneration systems, and thermionic burners.

Transportation. The major opportunities for petroleum savings in transportation are through improved heat engine efficiencies of vehicles and the substitution of more abundant domestic fuels for petroleum. The specific objectives of the DOE advanced heat engine program include at least 30% fuel economy improvement, while meeting emission safety and noise standards, having alternative fuels capability and being cost competitive. Results of the DOE program to date includes successful testing of two automobile gas turbine engines with some 75 ceramic parts, at high speed (in excess of 69,000 rpm), and high temperatures (in excess of 2,000°F). Two Mod I automotive Stirling engines have been provided to industry for their independent testing and evaluation. An advanced, heavy duty, turbocompound diesel demonstrated a 6.5% improvement in fuel economy, and a Rankine bottoming cycle demonstrated a 13% over-the-road fuel economy improvement. The research program for an uncooled, reducedfriction, adiabatic diesel, with exhaust heat recovery, is forecast at 40-45% fuel efficiency improvement. Electric vehicle battery development achieved 897 deep discharge cycles, or the equivalent of 47,000 vehicle miles. An alternating current propulsion system has been developed that is lower cost, smaller, lighter, and more producible than any existing electric vehicle propulsion system. High temperature ceramic materials research projects have been initiated, as well as the construction of a High Temperature Materials Laboratory at the Oak Ridge National Laboratory. High temperature materials are required for improved heat engine efficiency.

Multi-Sector Research. The multi-sector Energy Conversion and Utilization Program undertakes activities that address specific problems associated with efficiency limits and fuel use capabilities of energy conversion and utilization systems . Research areas include combustion and thermal sciences, materials, biocatalysis, and tribology. Research has already begun to pay dividends. A major U.S. auto manufacturer has used results of combustion studies to determine optimal spark locations which will improve engine performance. An innovative spirally fluted (enhanced surface) heat exchanger tube has been shown to have double the heat transfer coefficient over smooth tubes with no increase in pumping power requirements. Feasibility of catalytic decarboxylation of acetic acid in waste streams to recover resources previously considered uneconomical has been proven. Desirable strength, creep, and corrosion-resistant properties of long-range ordered alloys and intermetallic compounds (classes of high-temperature materials) have been developed for potential application in advanced heat engines. Correlation of the lubricities of base stock oil fractions to their molecular structure will lead to formulation of better lubricants. These examples of long-range research will impact new generations of energy technologies and result across significant energy savings in all end-use sectors.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
ENERGY CONSERVATION
(Tabular dollars in thousands. Narrative material in whole dollars)

	FY 1984 Appropriation	FY 1985 Appropriation	FY 1986 Base	FY 1986 Request
Buildings and Community Systems				
Operating Expenses ...	$ 35,698	$ 40,113	$ 40,113	$ 35,100
Capital Equipment.....	1,500	1,225	1,225	2,200
Subtotal	$ 37,198	$ 41,338	$ 41,338	$ 37,300
Industrial				
Operating Expenses ...	$ 33,517	$ 29,769	$ 29,769	$ 35,500
Capital Equipment	0	2,156	2,156	0
Subtotal	$ 33,517	$ 31,925	$ 31,925	$ 35,500
Transportation				
Operating Expenses ...	$ 55,658	$ 52,363	$ 52,363	$ 39,965
Capital Equipment	0	2,940	2,940	0
Plant	9,000	6,469	6,469	3,010
Subtotal	$ 64,658	$ 61,772	$ 61,772	$ 42,975
State and Local				
Operating Expenses ...	$280,166	$283,149	$283,149	$225,579
Subtotal	$280,166	$283,149	$283,149	$225,579
Multi-Sector				
Operating Expenses ...	$ 12,722	$ 21,676	$ 21,676	$ 25,700
Capital Equipment	0	1,666	1,666	1,000
Subtotal	$ 12,722	$ 23,342	$ 23,342	$ 26,700
Policy and Management				
Operating Expenses ...	$ 1,280	$ 1,727	$ 1,727	$ 2,600
Subtotal	$ 1,280	$ 1,727	$ 1,727	$ 2,600
Policy Analysis				
Operating Expenses ...	$ 750	$ 245	$ 245	$ 0
Subtotal	$ 750	$ 245	$ 245	0
Facilities				
Plant	$ 0	$ 15,681	$ 15,681	$ 0
Subtotal	$ 0	$ 15,681	$ 15,681	$ 0
Operating Expenses ...	$419,791	$429,042	$429,042	$364,444
Capital Equipment	1,500	7,987	7,987	3,200
Plant	9,000	22,150	22,150	3,010
Total Energy Conservation.	$430,291[A]	$459,179[B]	$459,179	$370,654[C]

[A] Reflects allocation of $840,000 in reductions for SBIR

[B] Reflects savings of $931,000 for Section 2901 of the Deficit Reduction Act of 1984 (P.L. 98 - 369).

[C] The FY 1986 amounts do not reflect a reduction of $4,000,000 for estimated prior year deobligation Management Initiative Savings

DEPARTMENT OF ENERGY
1986 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
ENERGY CONSERVATION
BUILDINGS AND COMMUNITY SYSTEMS

(Tabular dollars in thousands. Narrative material in whole dollars)

Building & Community Systems	FY 1984 Appropriation		FY 1985 Appropriation		FY 1986 Base	FY 1986 Request
Building Systems	$13,841		$14,897		$14,897	$12,900
Residential Conservation Service	480		1,274		1,274	400
Community Systems	4,200		5,390		5,390	2,000
Urban Waste	1,500		980		980	0
Technology & Consumer Products	9,957		9,997		9,997	9,400
Appliance Standards	1,693		2,450		2,450	2,000
Analysis & Technology Transfer	199		980		980	3,400
Federal Energy Management Program	996		1,274		1,274	1,500
Program Direction	2,908		2,871	*	2,871	3,500
SUBTOTAL						
Operating Expenses	35,698	**	40,113		40,113	35,100
Capital Equipment	1,500		1,225		1,225	2,200
TOTAL Building & Community Systems	$37,198	**	$41,338		$41,338	$37,300
Staffing Total FTE's	61		71		71	56

* Reflects savings of $24,000 for section 2901 of the Deficit Reduction Act of 1984 (P.L. 98-369).

** Reflects allocation of SBIR assessments including $76,000 against the former BCS Small Business subprogram.

Authorization: Pub. L. 93-577, as amended, Energy Research and Development Act
Pub. L. 94-163, Part E (Sec. 381), Energy Policy and Conservation Act
Pub. L. 94-385, Energy Conservation and Production Act
Pub. L. 94-438, Energy Reorganization Act of 1974
Pub. L. 95-618, (Title I), Energy Tax Act
Pub. L. 95-619 (Sec. 224, Parts 1, 2, 4; Sec. 210-223; and Sec. 501, 541-551), National Energy Conservation Policy Act
Pub. L. 95-620, Power Plant and Industrial Fuel Use Act of 1978
Pub. L. 96-294, Energy Security Act
Pub. L. 96-702, Emergency Energy Conservation Act of 1979

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
ENERGY CONSERVATION
BUILDINGS AND COMMUNITY SYSTEMS
(In thousands of dollars)

FY 1985 Conference Mark less 2901 rescission	$41,338
Built in increases and decreases:	
None	0
FY 1985 Adjusted and 1986 base	$41,338
Program increases and decreases:	
Building Systems	
o Building materials	-370
o Envelope subsystems (wall & roof)	+350
o Infiltration, ventilation and indoor air quality	+13
o Windows and daylighting	-976
o Building energy controls	+100
o Performance calculations	-425
o Performance monitoring and field validation	+400
o Residential building systems interaction	-423
o Commercial building systems interaction	-427
o Lighting quality metric	+200
o Construction quality	+100
o Design process research	+100
o Research utilization	-295
o Building energy retrofit research	-466
o Energy conservation standards and guidelines	+122
Subtotal	$-1,997
Residential Conservation Services	
o RCS	-490
o CACS	-384
Subtotal	$ -874
Community Systems	
o Scranton steam district heating system renovation	-1,505
o Integrated community energy systems	-1,885
Subtotal	$-3,390
Urban Waste	
o Integrated into Biofuels program	$ -980
Subtotal	$ -980

Technology and Consumer Products

o Thermally activated heat pumps	-300
o Refrigeration systems and appliance technology	-100
o Combustion heating equipment	- 97
o Equipment integration, lighting	-100
Subtotal	$ -597

Appliance Standards

o Test procedures	+18
o Consumer education	+2
o Appliance standards development	-470
Subtotal	$ -450

Analysis and Technology Transfer

o IEA support	-100
o Energy efficient building centers	+100
o Research utilization	+500
o Consumer decision research	+400
o Utility application	+400
o Fellowship program	+400
o Rural Housing Act study	+700
o Technical assessment analysis	+20
Subtotal	$+2,420

Federal Energy Management Program

o Planning and technical guidance and assistance	+226
Subtotal	$ +226

Capital Equipment

o Research and field test equipment	+975
Subtotal	$ +975

Program Direction

o 5% pay cut reduction	-139
o 2901 rescission	-24
o Contractor support	+466
o Price out of staffing	+326
Subtotal	$ +629

1986 budget request	$37,300

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET SUBMISSION
NARRATIVE JUSTIFICATION
ENERGY CONSERVATION
BUILDINGS AND COMMUNITY SYSTEMS

The goal of the Buildings and Community Systems (BCS) program is to advance technologies that will increase the energy efficiency of the built environment. This goal is being achieved through a comprehensive research program, transfer of the results of this research to the private sector, and implementation of DOE's statutory responsibilities in the buildings area.

Accomplishments in FY 1984 and expected in FY 1985 include:

- Published an assessment of urea-formaldehyde foam insulation technical issues, including existing standards, the properties of the foam, and techniques for their measurement. The report will be used by the public sector (e.g., Consumer Product Safety Commission, Department of Housing and Urban Development, and State energy offices) and the private sector (e.g., testing laboratories, researchers, potential vendors, and installers).

- Completed calibration of the mobile window thermal test unit that measures the energy performance of fenestration (i.e., window and daylighting systems). Developed fenestration design guidelines being used to update the ASHRAE Consensus Standard 90 and Handbook of Fundamentals.

- Developed inexpensive passive monitors for measuring carbon monoxide and humidity levels in buildings. These monitors complement formaldehyde, air infiltration, and other monitors developed by DOE and now commercially available. They make it possible, for the first time to measure indoor air quality at a relatively low cost.

- Completed detailed systems integration research on small office buildings and developed a handbook for architects, engineers, and building owners. The handbook which shows how conservation features can be combined to maximize energy savings and cost-effectiveness received a national buildings research award. A major industry publisher is printing and marketing the handbook at its own expense.

- Completed guides and began development of voluntary standards for new residential and manufactured housing. Issued Notices of Proposed Rulemaking on interim Federal residential standards, interim voluntary standards for private commercial buildings, and mandatory standards for new Federal buildings.

- Identified more cost-effective methods of retrofitting residences. Provided funds to the Alliance to Save Energy to test new retrofit approaches and evaluate their results. Through a partnership with States, obtained a commitment of funds that has exceeded the Federal support of this project.

- Identified the essential components of effective home energy rating systems, examined consumer attitudes and needs, assisted in the development of training materials, and initiated evaluation of the costs and impacts of rating systems now in use.

- Implemented the Residential Conservation Service (RCS) Federal Standby Plan in six States and completed an evaluation of the RCS program and submitted it to Congress. Implemented the Commercial and Apartment Conservation Service (CACS).
- Awarded grants to 10 communities to prepare feasibility studies for new district heating and cooling systems. Initiated research on low-cost heat meters and piping and the conversion of old steam district heating systems to modern hot-water systems.
- Completed analytical studies and initiated laboratory proof-of-concept research on three advanced absorption cycles for commercial and residential heat pump applications. This research will establish the previously unanticipated potential of absorption-type thermally activated heat pumps to achieve a 50% reduction in energy use compared to a condensing gas or oil furnace.
- Completed a one-year field test of an advanced refrigeration system for supermarkets, and transferred the technology to the private sector. The system uses multiple parallel compressors and advanced controls to effect a 29% energy savings.
- Demonstrated in the laboratory a 20% efficiency improvement for metal halide lamps through the introduction of novel gases and a 10% improvement for fluorescent lamps through enrichment with mercury 196 and 201 isotopes.
- Completed the initial analysis and field experiments on the integration of heating, ventilation, air conditioning, and lighting in buildings. Developed an equipment simulation model and long-term research plan. The optimal integration of this equipment has been given little attention, yet it can produce potential savings of 20-30%.
- Issued final rules amending test procedures for water heaters to include heat pump water heaters and for central air conditioners to reduce test burden and increase accuracy.
- Reviewed models and techniques for estimating the potential benefits of research projects, established an analysis plan for assessing technologies, and developed a multiyear BCS program plan.
- Assisted Federal agencies in developing, implementing, and evaluating shared-savings projects (private sector participants fund agencies' energy saving practices, techniques and equipment, and "share" with the government the savings accruing from these actions).
- Initiated design and construction of an Advanced Roof Testing Center at Oak Ridge National Laboratory. The Center will be used for both public and private sector research to evaluate the thermal performance of different roofing systems. These results will contribute to voluntary standards and guidelines for optimizing the energy performance of roofs.

Departmental Request

Funding of $37,300,000 is requested for the Buildings and Community Systems program in FY 1986. This is $4,038,000 less than the FY 1985 appropriation. The activities to be funded include the following subprograms:

- Building Systems
- Residential Conservation Service
- Community Systems
- Technology and Consumer Products
- Appliance Standards
- Analysis and Technology Transfer
- Federal Energy Management Program
- Capital Equipment
- Program Direction

Building Systems $12,900,000

The Building Systems subprogram has the objective of advancing the scientific, engineering, and architectural understanding of energy use in buildings. The results of this research are communicated to all sectors of the building industry. This subprogram also includes implementation of the Congressionally mandated requirements for Energy Conservation Standards and Guidelines for New Buildings.

The subprogram is organized under five key activities: Materials, subsystems, systems integration, energy retrofit research, and standards and guidelines. Building materials research deals with the energy characteristics of new and existing building materials. Building subsystems research considers walls, roofs, windows, and air movement. Building systems integration looks at how these subsystems are integrated into energy efficient whole buildings. Building retrofit research focuses on the special problems associated with improving the energy performance of the nation's existing stock of buildings. Standards and guidelines work fulfills statutory requirements.

The FY 1986 budget request for the Building Systems subprogram is $12,900,000. This funding level will allow continuation of some research started in earlier years, the expansion of some research activities, and the funding of new initiatives to replace some current efforts.

Building Materials Research: FY 1986 funding requested for building materials research will continue support of studies to develop and improve basic physical, chemical, and mechanical properties data for thermal insulations, low-density concrete, wood, and air and vapor retarders, to the extent that these properties influence the effectiveness, durability, safety, and health impacts of these materials when used for energy conservation in buildings. An R-value test procedure will be developed for reflective foil insulation, and improvements in moisture and thermal properties measurements will be investigated. Data from these efforts will be used to develop simulation models for predicting energy performance of materials and to reduce the need for laboratory and field testing.

Building Subsystems Research: FY 1986 funding requested for building subsystems research will be used to continue to advance the scientific and technical understanding of the energy performance of the basic features of buildings. This includes research on the walls, roofs, and windows which make up the building envelope and research on the movement of air through the building envelope and within the building.

Wall research will expand slightly to permit both dynamic wall and thermal mass research to continue. This will include development of protocols for dynamic testing of walls in a calibrated hot box; studies on heat losses in walls due to thermal bridges, bypasses and convective loops; a study of concrete structural thermal breaks; and studies of thermal mass effects in multifamily buildings.

Roof research will also expand slightly to support the development of a Roof Test Center. This research includes development of a roof simulation model to simulate effects of thermal, moisture, and internal stresses on roof systems. Small roof sections will be tested for thermal and moisture migration using the outdoor roof test apparatus and a test protocol will be developed for environmental chamber testing of whole roofs.

Windows and daylighting research will be reduced to permit new starts in other areas. Research will continue on advanced concepts for fenestration materials and models for characterizing their performance including surface microstructures and gradient index materials. The research will include development and improvement of models for predicting and analyzing both the thermal and daylighting aspects of windows and skylights and their energy efficiency impacts on building equipment and components. The second series of MoWiTT (Mobile Window Thermal Test facility) tests will be used to validate earlier component studies and tests, and to initiate testing of advanced window systems configurations.

Infiltration, ventilation and indoor air quality research will continue to develop and validate techniques for measuring, modeling, and controlling air infiltration, air leakage, and ventilation. This research will include studies on zonal ventilation balances; air movement in commercial buildings; impact of reduced air change rates on indoor air quality; improved techniques for mitigation and control of pollutants that affect health and comfort; materials emissions; the distribution of radon levels in the United States; and radon building-entry mechanisms. Field studies for mitigation of radon in buildings, collaborative efforts with American Society of Heating, Refrigerating, and Air-Conditioning Engineers to develop voluntary consensus minimum air quality standards, and the development of an indoor air quality data base will also be continued.

Building Systems Integration Research: The funding requested for building systems integration activities will support research in performance calculations, control systems, field validation and performance monitoring, the effect of construction quality on energy use, residential and commercial building system interactions, the development of a lighting quality metric, and the effect of design processes on building energy efficiency.

Performance calculations research will continue to develop an advanced energy use simulation program and to maintain the existing DOE-2 simulation program. New capabilities for DOE-2 including new mechanical equipment systems will be developed, tested, and validated, and the existing code and documentation will be maintained. Program modules for the advanced simulation program will be developed, tested, and validated. In the building energy controls area, development of advanced simulation models for evaluating the dynamic interactions among building envelope, space conditioning equipment, other energy-using systems and building controls will be resumed.

Field validation and performance monitoring research will continue to evaluate the performance of materials, components, and subsystems in operational settings and the interaction of subsystems and how they affect both annual and peak energy use in different building types under different operating and climatic conditions. Performance data for two commercial building types will be collected in a hot-humid climate, and systems level residential performance monitoring to evaluate innovative energy saving strategies for hot-humid regions will begin. Field validation of radiative and convective wall and roof performance in residential buildings (initiated in FY

1984) will be completed, and studies will address the thermal effects of infiltration and moisture in hot-humid climates. Research initiated on the performance of composite metal walls and roofs in small buildings will make data available for verification of mathematical models, laboratory tests, and advanced design and construction techniques.

Construction quality research addresses the influence of levels of construction quality and specific residential construction techniques as they influence the overall energy efficiency of residences. Emphasis is placed on new or emerging construction techniques such as panelized, modular, and Japanese robotic-developed housing sections. Other issues such as proper detailing, construction sequencing and economics as they influence builder energy decisions are pursued. Simulated and actual energy data are used to determine poor practices, and develop recommended alternate techniques and practices. Work in FY 1986 will be of a planning nature including establishment of a preliminary research agenda.

The residential systems interactions activity develops an understanding of the effectiveness of residential design features operating together for effective energy use in housing. Studies are conducted consistent with new housing trends for hot-arid and hot-humid climates. These include garden-style multifamily dwellings and modular and manufactured housing. Critical technical design issues are also pursued irrespective of building style. These include the interactive influence of thermal mass, windows and orientation; microclimate analyses; and the development of design tools, such as conservation sliderules and microcomputer programs. During FY 1986, work applicable to hot-humid and hot-arid climates will continue. Analysis of microclimate design considerations and predictions, and measurement of actual energy predictions in hot-climate dwellings will be carried out.

The commercial building systems interactions activity recognizes that energy efficient buildings cannot be designed simply by arbitrarily assembling good components. This program consists of both mid-term and long range research activities including studies of individual building types, development of performance targets with industry, the complex logic of energy efficient commercial building interactions, and the integration of advanced designs and high efficiency components. Research on complex interactions of retail facilities will be performed in FY 1986.

The lighting quality metric activity is needed because less is known about lighting quality in the context of the entire building than any other area of commercial building design, yet lighting is the primary component of most commercial building monthly energy bills. There is a published, commonly accepted definition of thermal comfort in buildings and this forms the fundamental basis for all research on building thermal energy use. No such definition exits for lighting comfort and the resulting impact on user productivity. FY 1986 funding will be used to initiate research on the correlation between luminance relationships and occupant comfort and productivity. Establishment of other quantitative fundamentals necessary for industry to develop a definition of lighting quality will also be initiated. DOE will consider this definition in its commercial buildings energy conservation standards and guidelines.

The design process research activity will use FY 1986 funding to initiate research on existing processes in planning, implementing, and designing projects. The design process will be characterized from inception through development, programming, schematic design, design development, and production of working drawings. Critical decision points that affect future energy performance will be identified so that research results can be focused on these decision points.

Building Retrofit Research: Research will be continued to improve building energy retrofit technologies and to strengthen non-Federal mechanisms for accelerating the adoption of such technologies. Field tests have shown that actual energy saved from the application of retrofit measures is often lower than engineering estimates of projected savings. A program to better understand how retrofit measures actually perform in residential and commercial buildings, to determine the energy impact of retrofits attributable to such factors as quality of installation, and to identify the most suitable retrofits for various types of buildings, particularly for multifamily dwellings, will be continued. Research will also continue on key retrofit technologies and methods to strengthen market mechanisms for achieving building retrofit.

Energy Conservation Standards and Guidelines: The standards and guidelines activity is a multi-year effort in two program areas designed to meet both statutory requirements and the needs of particular sectors of the buildings industry. Research, public review and comment, analysis, and publication of standards and guidelines are required to meet the statutory responsibilities of P.L. 94-385, as amended. The first program area is concerned with residential buildings. FY 1986 funding will be used to continue development of voluntary residential and manufactured housing standards for the private sector. Also, funding will be used to initiate a statutorily required demonstration of the mandatory Federal standards. In the second program area, commercial building voluntary guidelines for the private sector and mandatory standards for Federal buildings are being developed. FY 1986 funding will be used to continue demonstration of commercial building standards and guidelines.

Residential Conservation Service $400,000

The FY 1986 budget request for the Residential Conservation Service subprogram is $400,000. The funds will be used for the Commercial and Apartment Conservation Service (CACS) activity as mandated by the National Energy Conservation Policy Act (NECPA), and amended by the Energy Security Act (ESA). No funds are requested for the Residential Conservation Service (RCS) activity. The requirement that utilities disseminate RCS program announcements terminated January 1, 1985. It is expected that the provision of audits by utilities will phase down and that there will be little DOE activity on RCS after FY 1985. Thus, the FY 1986 budget request is lower than the FY 1985 appropriation, which covers both RCS and CACS.

The funding requested for FY 1986 will support the continued implementation and evaluation of the CACS program and the CACS Federal Standby program. The funds will be used to support technical review of CACS State plan amendments and CACS Standby procedures proposed by utilities in Federal Standby States, to provide limited technical assistance to States and CACS Federal Standby utilities, and to monitor and evaluate both CACS and CACS Federal Standby programs.

Community Systems $2,000,000

The objective of the Community Systems subprogram is to improve the efficiency of energy use in communities. The subprogram conducts research related to energy supply, energy use and their integration at the community level. With regard to energy supply, this subprogram focuses on district heating and cooling (DHC). Other aspects of community energy supply are addressed by other DOE programs. Various Federal, state, and local programs address energy use by individuals within communities. To complement these efforts, this subprogram focuses on community energy planning, development and management.

A multi-year plan for the Community Systems subprogram was completed in 1984 as required by Congress. The emphasis of the plan is on long-term, high-risk research on critical issues and away from the large proof-of-concept demonstrations funded by DOE in the past. The plan states that a DOE role is appropriate only when there is a high-priority need that non-Federal organizations cannot or will not address, or can address only with Federal support and involvement.

The FY 1986 budget request for Community Systems is $2,000,000. This represents a $3,390,000 decrease from the FY 1985 appropriation. Funds were provided in FY 1985 for the Urban Consortium and the renovation of an old district heating system in Scranton, Pa. No new funding is requested for these activities in FY 1986 since they will be completed with the funds appropriated for FY 1985.

District Heating and Cooling: District heating and cooling (DHC) systems can increase the thermal efficiency of power plants from about 33% to more than 80%, permit the substitution of coal and local resources for oil and natural gas, create jobs, and contribute to the revitalization of urban areas. Despite these advantages, there are impediments to the widespread use of DHC systems, which include their cost and the absence of any central, organizational entity in most cities. The FY 1986 program will continue to address these barriers. The high cost of DHC systems and components will be addressed through cooperative research with the private sector to develop low cost piping systems and low cost heat meters and the identification of cost-effective strategies for retrofitting old steam systems, the most prevalent DHC systems in the United States today. The expansion of DHC systems into the growing "Sun Belt" cities will be supported through research on improved district cooling technologies. FY 1986 funding will also continue support for cities to assess the technical, institutional, and financial feasibility of adopting DHC systems. The dissemination of research results to potential users will continue, as will support for the exchange of information on DHC technologies between U.S. and foreign researchers.

Community Energy Planning, Development and Management: This activity provides assistance to increase energy efficiency in local government facilities and services, in community and neighborhood land use practices, and in matching local energy supply and demand requirements. In FY 1986 the focus will be on identifying site-specific design features that reduce energy use in building clusters.

Urban Waste $0

This subprogram has been integrated into the Biofuels program and is discussed as an integral part of the justification for that program. Consequently, no funding for Urban Waste activities is requested in the FY 1986 Buildings and Community Systems budget.

Technology and Consumer Products $9,400,000

The purpose of the Technology and Consumer Products subprogram is to provide the technological basis for improved, energy efficient building energy conversion processes and equipment. Research programs investigate, develop and test generic technical approaches and engineering concepts with potential for substantially increasing the efficiency of the conversion of raw energy in the form of oil, gas, solid fuels, and electricity into useful energy in the form of heat, refrigeration, and lighting. This subprogram consists of five key activities: thermally activated heat pumps, refrigeration and appliances technology, combustion heating systems, light sources, and equipment integration. The FY 1986 budget request for these activities is $9,400,000. This is $600,000 less than the FY 1985 appropriation.

Thermally Activated Heat Pumps: This activity consists of research on the technologies supporting heat engine-driven and absorption heat pump systems. These systems obtain high efficiencies by utilizing natural gas or oil to drive a heat pump cycle, providing potential coefficiencies of performance (COP) of 1.8 or 2.0, compared with maximum COP's of 0.95 for conventional heating technology. The multiyear research program is conducting proof-of-concept research on novel cycle absorption heat pumps and free piston-driven systems in FY 1985. In FY 1986, proof-of-concept testing of three novel absorption cycles will continue at the laboratory breadboard stage and will include the effect of higher-temperature fluids. Development of a hydraulic compressor drive system for free-piston Stirling engines will continue with the analysis and design of a second-generation breadboard system. A field test of a free-piston internal combustion engine-driven heat pump in a commercial building will be initiated.

Refrigeration and Appliance Technology: This activity consists of research on the basic technologies (e.g., heat transfer and physical properties of working fluids) associated with electric heat pump cycles, commercial refrigeration, and appliance insulation. Advances in these systems will lead to performance improvements of 40% compared to state-of-the-art technology. The multiyear research program is conducting laboratory research on basic phenomena and supporting field experiments in FY 1985. In FY 1986, research will continue on heat and mass transfer and phase change in ground heat exchange processes, on nonazeotropic mixtures including composition control processes, on heat pump dynamic loss characterization, on advanced appliance insulation heat transfer phenomena, and on the dynamic response of commercial building energy conversion equipment.

Combustion Heating Systems: This activity consists of research on gas, oil, wood and coal combustion, and on heat transport phenomena. Advances in these basic technologies will allow heating systems to achieve maximal seasonal efficiencies. The multiyear research program focuses on materials research and assessments in FY 1985. For FY 1986, the program will include research on advanced nonmetallic and composite materials for condensing heat exchangers and fundamental research on combustion and heat exchange processes, including those involving solid fuels (wood and coal).

Light Sources: This activity consists primarily of research on the basic phenomena of light sources and systems. Advanced lighting technology has the potential for a 50% or greater reduction in lighting energy consumption. The major focus of this multiyear program has been on the basic plasma physics of discharge lighting. In FY 1985, the program is initiating research on advanced diagnostic techniques for lighting plasmas. In FY 1986, research will continue on mercury isotopes, the magnetic field (Zeeman) effect, novel gas fills, and high frequency operation. This research will be augmented by continued development of diagnostic techniques to characterize the phenomena.

Equipment Integration: This activity consists of some research previously conducted under the lighting and combustion heating key activities and new research aimed at developing an understanding of occupant and building impacts, systems integration and distribution, and their impact on building equipment efficiency. As an example of the energy savings potential, effective application of residential zoning and elimination of duct losses can each save up to 30% of heating and cooling energy. In FY 1986, research will be initiated on warm-air duct losses and zoning strategies in residential and commercial buildings and will continue on HVAC/lighting/envelope interaction, thermal comfort/equipment optimization, and dynamic simulation of warm air distribution systems.

Appliance Standards $2,000,000

The purpose of the Appliance Standards subprogram is to develop test procedures for measuring the energy efficiency of household appliances, to analyze the need for appliance standards, and to support related education programs. These subprogram activities are required by the Energy Policy and Conservation Act (EPCA), as amended. The household appliance requirements of EPCA are divided between DOE and the Federal Trade Commission (FTC). The FTC is directed to require energy efficiency labels on major household appliances. DOE is directed to develop the test procedures used in developing these labels.

The FY 1986 budget request for Appliance Standards is $2,000,000. This is $450,000 less than the FY 1985 appropriation. The decrease will be achieved by stretching out the reanalysis of the need for appliance standards.

Test Procedures: Test procedures for 13 types of household appliances have been developed since 1978 in support of the FTC appliance labeling program. In FY 1985, the Department will, as required by legislation, continue to improve test procedures. The Department will amend the water heater test procedures to include heat pump water heaters and will initiate a rulemaking so that the test procedures for central air conditioners are more accurate and less costly to perform. In addition, manufacturers' requests for waiver of appliance test procedures will be processed. In FY 1986, the Department's test procedure activities will focus on improving the test procedures for refrigerators and refrigerator-freezers, central air conditioners, and furnaces to make them more accurate and less burdensome and to include new appliance designs. Also, in FY 1986 the Department will continue to process test procedure waiver requests.

Consumer Education: In FY 1985 DOE will continue to support the FTC labeling program through efforts to increaseoconsumer awareness of and attention to the information on the label, and to encourage greater use of label information in making purchase decisions. Work in this area includes gathering and providing FTC with current information on consumer response to the label and determining the scope and impact of materials currently available from Government, utilities and manufacturers. Activities planned for FY 1986 include updating DOE materials explaining the labeling program and cooperative efforts with trade associations to improve the exposure of labeling information and to strengthen dealer training programs. In anticipation of FTC's pending rulemaking to require labels for central air conditioners, DOE is preparing to provide support to create consumer awareness of the central air conditioner label and to educate consumers on the use of the information on that label.

Appliance Standards: Rulemakings have been completed for eight types of appliances. In FY 1985, the Department will continue a reanalysis and reevaluation of the efficiency standards promulgated by these rulemakings. Reanalysis activities will focus on completion of the review of the existing analytic system, and research on the effect of standards on manufacturers, consumers, and the nation. The Department will conduct a rulemaking regarding standards for four categories of products (dishwashers, television sets, clothes washers, and humidifiers/dehumidifiers). The standards rulemaking process for three products (heat pump, heat pump water heaters, and home heating equipment) will be initiated. In addition, the Department will continue to process State petitions not to be preempted by Federal appliance standards. Activities planned for FY 1986 include continuing the reanalysis effort with development of a detailed analysis of consumer and manufacturer impacts as well as research on utility impacts. The three-product analysis will be completed and a proposed rule will be prepared and issued for public comment. The processing of State petitions will continue.

Analysis and Technology Transfer $3,400,000

The Analysis and Technology Transfer subprogram analyzes building industry and technology trends to identify research priorities, transfers the results of buildings research to the private sector, and carries out related support efforts. The key activities include: 1) support for the collaborative building research of the International Energy Agency (IEA), 2) technical assessments and planning analyses, 3) utility research programs, 4) consumer decision-making research, 5) the Rural Housing Amendments Act study, 6) research utilization, 7) Energy Efficient Buildings Centers, and 8) research fellowships.

The FY 1986 budget request for this subprogram is $3,400,000, which represents an increase of $2,420,000 above the FY 1985 appropriation. This increase is due to the transfer of all BCS technology transfer activities into this subprogram and the expansion of these efforts, to new research initiatives in consumer decision-making and utility programs, and to the funding of a study mandated by the Rural Housing Amendments Act of 1983.

IEA Support: These activities include support for IEA implementing agreements, transfer of the results of IEA research to the U.S. private sector, and arranging U.S. private sector participation in IEA activities. The agreements provide for collaborative research in building systems, district heating, and advanced heat pumps.

Technical Assessment and Analyis: This activity involves obtaining data on energy use in the buildings sector and on the effectiveness of new technologies and, after analysis, providing information to the BERD staff for use in program planning. The activity monitors research activities and oversees the transfer of the results to the private sector and other users through publications and workshops, often held in cooperation with the private sector.

Utility Applications: This is a new initiative to stimulate voluntary utility energy conservation programs, but with more flexibility than past mandatory programs. The building sector is the dominant user of electricity--60% of total sales-- making building end-use programs the primary area where utilities can influence demand, particularly peak demand. This initiative will support innovative utility programs in the buildings sector and disseminate the results to other utilities. Major private sector joint funding is anticipated.

Consumer Decision Research: This is a new research initiative to develop information about consumer behavior so that it can be considered in the planning and evaluation of building energy research programs. The successful introduction of new technologies often depends upon individual consumer responses, an area that has received only limited scientific study. The findings should improve the effectiveness of such programs as appliance labeling, home energy rating systems, and voluntary building energy performance standards. This initiative has been recommended in a report by the National Academy of Sciences.

Rural Housing Amendments Act Study: Section 503(b) of the Rural Housing Amendments Act of 1983 requires DOE to compare the increased construction costs, the actual annual energy use, and the projected value of energy saved in manufactured homes built to national manufactured housing safety standards with other homes elegible for loans or insurance under HUD's Title I or Title II programs and Farmers Home Administration Title V program.

Research Utilization: This activity was formerly a part of the Building Systems subprogram. The design competition for architectural students will be continued as well as the summer institutes for architectural and engineering faculties and the development of design tools, techniques and specific information packages for architects, engineers, and builders.

Energy Efficient Buildings Centers: The proposed centers would serve as a clearinghouse to transfer the results of research on new materials, equipment and technologies to architects, engineers and builders. The centers also would support regional and mobile displays of new technologies. The centers would be heavily leveraged with private funds. The funds requested in FY 1986 will be used to determine the feasibility of the proposed centers and determining the level of private sector interest.

Fellowship Program: This activity would promote technology transfer by suppoprting study and research at the national laboratories by private sector researchers; university students, faculty members and researchers; and staffs of public organizations.

Federal Energy Management Program $1,500,000

The Federal Energy Management Program (FEMP) is a federally directed effort to reduce energy use by Federal agencies, improve utilization efficiency, conserve scarce fuel, and transfer energy management experience among Federal agencies, State and local governments, and the private sector. The FY 1986 budget request for FEMP is $1,500,000. This represents $226,000 more than the funding appropriated for FY 1985.

FY 1986 funding is necessary to continue planning for the implementation of Federal laws and Executive Orders pertaining to energy conservation in the Federal government; prepare annual reports to the President and Congress; monitor Federal agency conservation activities and performance; assist agencies in developing and implementing energy conservation programs; and provide them with technical guidance (i.e., "How to" manuals and workshops on life cycle cost analysis, "Energy in Design", and employee awareness programs). The technical assistance program will be expanded to include counseling on shared savings contracting. "How to" manuals will be updated, and evaluation of Federal shared savings contracts will be initiated. The information clearinghouse on shared savings will be expanded to incorporate material and data from cities and states which undertake shared savings projects and the mechanism for distributing materials to the private, non-profit and public sector will be broadened.

Capital Equipment $2,200,000

The purpose of the Capital Equipment subprogram is to provide items of laboratory and test equipment needed to support all Buildings and Community Systems subprograms. These items are required to carry out planned research activities at participating national laboratories and universities. The FY 1986 budget request for capital equipment is $2,200,000. This represents an increase of $975,000 compared to the FY 1985 appropriation.

The FY 1986 funding will be used for: (1) roof systems test equipment, laboratory analytical materials, research and field test equipment to support heat pump and absorption technology work, and building insulation testing apparatus at Oak Ridge National Laboratory; (2) plasma diagnostic equipment to support advanced lighting research, and diagnostic and computer data logging equipment to support research on health effects of advanced lighting at Lawrence Berkeley Laboratory (LBL); (3) laboratory and test equipment in support of windows and daylighting and heat transfer work at National Bureau of Standards and LBL; (4) equipment in mobile vans for on site measurement of the components of building energy use in support of the Federal Energy Management Program; (5) laboratory analytical materials research equipment for district heating and cooling systems; and (6) laboratory equipment used in development of appliance test procedures.

A climatic test chamber for controlled quantitative testing of 12 foot square roof panels will be designed and fabrication will be initiated on the basic chamber. This chamber will form the core of an advanced Roof Test Center at Oak Ridge National Laboratory. This capability will permit cooperative industrial, academic, and governmental research to develop a quantitative understanding of the thermal performance of roof systems. These results will provide an improved scientific and technical basis for private sector design and development of longer lasting, more energy efficient roofs.

Program Direction $3,500,000

The FY 1986 budget request for Program Direction is $3,500,000. This represents a $629,000 increase compared to the FY 1985 appropriation.

The requested funding will provide staffing at the level of 56 FTE's to manage the Buildings and Community Systems program. This is 15 FTE's less than the FY 1985 allowance. The request includes funding for contractor support required to assist in managing the eight BCS subprograms as well as funding for salaries, benefits and travel of the 56 FTE's.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
BUILDING SYSTEMS		
Building Materials Research	Envelope Materials: Continue development of technical data base and test procedures for insulating and building materials; complete loose-fill insulation stability-with-time study, urethane aging study, and testing of prototype standard reference materials and reflective foils; initiate work on technical gaps for low-density concrete, wood and wood products, moisture effects, vapor and air retarders, industrial insulations, and advanced insulator concepts. ($1,470)	Continue development of data base for low density concrete, plastic foams, reflective foils and vapor retarders; also develop improved moisture and thermal properties measurement capabilities and reflective R-value test procedure. ($1,100)
Building Subsystems Research	Walls and Roofs: Initiate calibrated hot box (CHB) testing of wall sections and prepare test protocol.	Complete CHB test protocol development, conduct test using protocol, and compare results with field tests of similar wall sections.
	Identify and characterize building envelope thermal anomalies (BETAS) and continue concrete structural thermal break study.	Initiate test and validation of BETAS solutions. Complete concrete structural thermal break study.
	Establish benefits and limits of thermal mass (TM) in single family residential building walls.	Initiate validation of model for predicting TM effects in multi-family residential buildings.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Building Subsystems Research (Cont'd)	Continue development of roof model and perform tests on outside roof test apparatus (RTA) to collect data on thermal and moisture migration.	Continue development of roof model by integrating moisture with thermal and internal stress segments of the model. Continue thermal and moisture testing on RTA in support of model validation.
	Complete capacitance and nuclear magnetic resonance prototype instruments for locating, quantifying, and plotting movement of moisture in envelope systems. ($1,250)	Complete RTA testing of prototype moisture instrumentation. ($1,600)
	Windows and Daylighting: Expand fenestration materials studies to selectively control heat and light, including glass and plastic substrates, coatings, transparent insulators, fluorescent concentrators, surface microstructures, and gradient index materials.	Continue investigation and model development to characterize surface microstructures, and gradient index materials.
	Continue to develop experimental and analytical techniques to predict thermal and daylighting performance, addressing heat transfer in gaps, solar optical properties, and analytical and scale models.	Continue to develop experimental and analytical techniques including daylight availability as a function of climatic parameters, an improved sun source for the sky simulator, and the integrating sphere for component testing.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Building Subsystems Research (Cont'd)	Continue to study the net thermal and daylighting effect of fenestration. Complete mobil window test thermal (MoWitt) facility calibration and first series of systematic fenestration field tests.	Continue the study of net thermal and daylighting effect in buildings, the series of summer and winter MoWiTT tests covering multiglazed windows, and an initial commercial operable shading and daylighting system simulation study.
	Continue studies of fenestration impacts on occupants and the building. ($2,376)	Continue fenestration impact studies completing an assessment of the adequacy of existing comfort criteria. ($1,400)
	Infiltration, Ventilation, and Indoor Air Quality: Continue ventilation performance measurements in large buildings, using both active and passive tracer gas techniques.	Continue and compare infiltration and ventilation performance measurements in large buildings, using active and passive tracer gas techniques.
	Continue field validation of multichamber air leakage measurement systems.	Construct a multichamber infiltration and ventilation experimental apparatus to test multichamber air leakage measurement systems and models.
	Continue efforts to identify and quantify sources of indoor radon. Continue efforts to assess the variability of ambient radon levels and to characterize building entry mechanisms.	Continue assessment of the variability of ambient radon levels in the U.S., characterization of building entry mechanisms, and field studies on mitigation of radon in buildings.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Building Subsystems Research (Cont'd)	Develop and evaluate energy efficient and cost-effective control strategies to maintain indoor air quality.	Continue to develop, test, and evaluate energy efficient and cost effective control strategies to maintain indoor air quality.
	Initiate collaborative efforts to establish an indoor air quality field study data base.	Expand the indoor air quality field study data base.
	Continue collaborative efforts to develop voluntary consensus standards for indoor air quality, and interagency efforts to coordinate indoor air quality research. ($1,887)	Continue collaborative efforts to develop voluntary consensus standards for indoor air quality, and interagency efforts to coordinate indoor air quality research. ($1,900)
Building Systems Integration	Performance Calculations: Maintain DOE-2 building energy performance computer code. Update DOE-2 documentation and user manuals. Develop, test, and validate new capabilities for DOE-2, including new mechanical equipment types.	Continue DOE-2 maintenance and documentation efforts. Continue development, testing, and validation of new capabilities for DOE-2.
	Continue development of the advanced building energy performance simulation program, identifying interactive program modules. ($1,225)	Develop, test, and validate advanced simulation program modules. ($800)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Building Systems Integration (Cont'd)	Building Energy Controls: Complete series of reports analyzing controls strategies used in buildings; algorithms for air handlers and three optimization strategies; and an interactive front end model for a building/HVAC/control system simulation program. Continue work on development, verification and refinement of additional optimization algorithms and HVAC component models. (FY 1983 carryover funds)	Continue development of advanced simulation models for evaluating the dynamic interactions among building envelope, space conditioning and other energy-using systems, and building energy control systems. ($100)
	Performance Monitoring and Field Validation: Complete validation and case study of residential superinsulated envelope performance; continue monitoring and analysis of vent skin and radiative barrier performance in hot humid climates; and initiate performance monitoring of five commercial building types (ten buildings) in first climatic zone. (FY 1984 carryover funds)	Complete field validation of radiative and convective wall and roof performance of residential buildings in hot-humid climates. Begin systems level data collection of residential energy performance in hot-humid climates. Continue work on the performance of composite metal walls and roofs in small commercial buildings. Initiate performance monitoring of two commercial buildings in hot-humid locations. ($400)
	Residential Building Systems Interactions: Continue regional research activities including planning of hot-arid research and continuing activities	Continue studies of effects of microclimate on residential energy use. Begin investigating technical basis for regional residential stra-

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Building Systems Integration (Cont'd)	in hot-humid area. Develop a methodology to assess microclimatic influences on residential and manufactured energy performance. Complete single family guides. Establish technical basis for energy performance in garden apartments. ($1,123)	tegies in hot-arid climates. Field test results of research in hot-arid areas. ($700)
	Commercial Building Systems Interactions: Complete systems integration research of multifamily high-rise buildings. Continue development of energy performance targets with industry. Plan research on complex logic of commercial building interactions using expert systems artificial intelligence. Plan agenda for long-term systems integration of advanced subsystems and designs. Complete mid- and long-term research agenda. ($1,327)	Begin research on complex interactions of retail facilities. Examine interactive effects of mechanical system types, lighting system designs, and daylighting designs for five climates. Convene technical review panels including retail owner group to review research assumptions. Continue development of energy performance targets with industry. Complete base case building descriptions to be used in technical analysis. Derive initial targets for review for first set of building-load types. ($900)
	Construction Quality Research: None ($0)	Conduct initial program planning including determination of building types, construction types and construction techniques to be researched. Give particular attention to Japanese manufactured housing and Swedish panelized housing as they relate to U.S. technology. ($100)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Building Systems Integration (Cont'd)	Design Process Research: None ($0)	Initiate research on processes of planning, implementing, and designing projects. Characterize the design process from inception through development, programming, schematic design, design development, and production of working drawings. Identify critical decision points that affect future energy performance. ($100)
	Lighting Quality Metric: None ($0)	Initiate correlation of space luminance relationships to occupant comfort and productivity. Begin establishment of other quantitative fundamentals necessary for industry to develop a quantified definition of lighting quality and for DOE to consider in the commercial buildings energy conservation standards and guidelines. ($200)
	Research Utilization: Conduct institute for architectural and engineering schools and conduct architectural students "Buildings plus Energy" national design competition. Complete collection	(Funding requested in Analysis and Technical Transfer subprogram in FY 1986.)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Building Systems Integration (Cont'd)	of baseline data and post-occupancy evaluation (POE) of commercial building lighting quality. Evaluate opportunity to perform POE in other building types. ($295)	
Building Energy Retrofit Research	Single-Family Retrofit Research: Complete implementation of program to develop cost-effective mechanical equipment retrofit technologies for low-income occupants. Develop standard protocol which DOE and others can use to collect and assess field data on the impact of single-family retrofit measures. Design cost-shared research program to apply protocol to determine why single-family dwelling retrofits save significantly less energy than predicted. ($1,200)	Complete evaluation of mechanical equipment retrofit research program for low-income occupants and transfer results to States, utilities, and other potential users. Initiate data collection to determine why single-family dwelling retrofits save significantly less energy than predicted. ($800)
	Multi-family Retrofit Research: Initiate with HUD field monitoring of selected dwellings to determine the most cost-effective retrofit strategies for Federally-assisted multi-family housing. Develop standard protocol which DOE and others can use to collect and assess field data on the impact of retrofit measures for other types of multi-family residences.	Complete field monitoring of Federally assisted multi-family housing; determine most cost-effective retrofit strategies and transfer results to public housing authorities and other potential users. Initiate cost-shared research program to develop a retrofit strategy for all other types of multi-family buildings.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Building Energy Retrofit Research (Cont'd)	Design cost-shared research program to apply protocol to determine why multi-family dwelling retrofits save significantly less energy than predicted. ($980)	Develop methods for maximizing energy savings and minimizing secondary impacts on tenants. ($850)
	Commercial Building Retrofit Research: Develop standard protocol which DOE and others can use to collect and assess field data on the impact of commercial building retrofit measures. Design cost-shared research program to apply protocol to determine most cost-effective commercial retrofit strategies. ($685)	Identify key commercial building types and retrofit strategies for initial examination. Instrument selected buildings and initiate data collection to determine most cost-effective retrofit technologies for these types of commercial buildings. ($750)
Energy Conservation Standards and Guidelines	Begin development of voluntary residential and manufactured housing standards for the private sector and issue interim standards for Federal residential buildings. Issue interim commercial building standards. (These standards are voluntary guidelines for the private sector and mandatory standards for Federal buildings.) ($1,078)	Continue development of voluntary residential and manufactured housing private sector standards. Initiate statutorily required demonstration of the Federal Standards. Begin demonstration of commercial building guidelines and standards. ($1,200)
Subprogram Total	$14,897	$12,900

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
RESIDENTIAL CONSERVATION SERVICE Residential Conservation Service (RCS)	Review RCS plan amendments proposed by States and requests for waivers and exemptions proposed by utilities. Analyze and respond to technical inquiries from States, utilities, and other program participants. ($90)	(Utility requirement to disseminate RCS program announcements expired 01/01/85. It is expected that utility provision of audits will phase down thereafter and there will be little DOE activity connected with RCS after FY 1985.)
	Review and approve utility procedures for Federal Standby programs; maintain and update Master List of Contractors; investigate and resolve complaints. ($200)	
	Provide guidance to States and utilities on preparation of annual reports and prepare summary report; monitor utility supply, installation and financing activity; complete evaluation of RCS and Federal Standby program. ($200)	
Commercial and Apartment Conservation Service (CACS)	Review CACS plans and amendments proposed by States and utilities. ($84)	Review CACS State plan amendments proposed by States and utilities. ($100)
	Disseminate information on as needed basis on audit and retrofit techniques, measures evaluation, and audit assessment. ($100)	

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Commercial and Apartment Conservation Service (CACS) (Cont'd)	Initiate review of CACS plans proposed by utilities in Federal Standby States; analyze and respond to technical inquiries from utilities and other Federal Standby program participants; develop information on program implementation, including technical support and guidance documents, to Federal Standby utilities. ($300)	Review CACS plans proposed by utilities in Federal Standby States; continue to analyze and respond to technical inquiries from utilities and other Federal Standby program participants; continue to develop and disseminate information on program implementation, including technical support guidance documents to Federal Standby utilities. ($200)
	Provide guidance to States on preparation of annual reports and prepare summary report; monitor State and utility CACS programs; implement CACS evaluation plan. ($300)	Continue to provide guidance to States on preparation of annual reports and prepare summary report; continue to monitor State and utility CACS programs; continue to implement CACS evaluation plan. ($100)
Subprogram Totals:	$1,274	$400
Community Systems District Heating and Cooling (DHC)	Local Resource Use: Design and test simple and bundle down-hole heat exchangers for extracting heat from mine water in Scranton, PA, as a potential thermal source for DHC systems. (Funded from unexpended prior year obligations.)	No activity. ($0)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
District Heating & Cooling (DHC) (Cont'd)	Complete inventory of small (5-25mwt) solid fuel combustors available commercially and identify potential DHC applications. ($75)	
	Systems and Components Development: Initiate research on additives which can increase fluid flow and energy extraction in district cooling systems. Initiate research in methods to retrofit old DHC steam systems using Scranton, PA, system as a laboratory. Begin data base compilation in support of industry development of performance standards for thermal metering. Conduct inventory and analyze performance of piping systems as initial effort to reduce piping and installation costs. Competitively select other research projects to improve the cost-effectiveness of DHC systems and components; share costs with private sector. ($2,265)	Continue research in additives to increase fluid flow and energy extraction to improve district cooling systems. Continue research in methods to retrofit old steam systems, including conversion to hot water (with prior year funds). Complete testing and produce velocity field data and metering calibration information in support of industry performance standards development for thermal metering. Continue research on piping and innovative DHC systems and components projects systems selected in FY 1985 ($900)
	Systems Assessment, Methods and Results Dissemination: Competitively select 10-12 cities to assess the feasibility of DHC in their communities and initiate assessments. Develop methodology for analyzing the market potential and	Continue preliminary design work for DHC projects proven feasible. Select additional cities to assess the feasibility of DHC in their communities. Apply methodology to analyze market potential and

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
District Heating & Cooling (DHC) (Cont'd)	penetration level of alternative DHC systems. Continue dissemination of research results and information exchange. ($965)	penetration level of alternative DHC systems. Continue dissemination of research results and information exchange. ($900)
Community Energy Planning, Development and Management	Urban Consortium: Continue support for the Energy Task Force's research and technology transfer projects to improve energy efficiency in local government operations, community development and community energy planning. ($1,960)	No activity. ($0)
	Site Design: Develop methodology for evaluating the effect of siting, orientation and landscaping on energy use in building clusters. ($125)	Apply methodology and develop data base on various site design concepts that reduce energy use. ($200)
Subprogram Total	$5,390	$2,000
TECHNOLOGY AND CONSUMER PRODUCTS		
Thermally Activated Heat Pumps	Begin proof-of-concept testing and evaluation of novel absorption cycle heat pumps. Investigate an advanced free piston Stirling engine and internal combustion engine concepts. Evaluate	Continue proof-of-concept testing of three novel absorption cycles at the laboratory breadboard stage, including high-temperature fluid effects. Continue development of free-piston

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Thermally Activated Heat Pumps (Cont'd)	appropriate sealing technology and continue supporting research in free piston engine thermodynamics. ($4,500)	Stirling engine-compressor concepts concentrating on design of a second generation laboratory breadboard for the hydraulically driven concept. Initiate a preliminary field test of the free-piston internal combustion engine-driven heat pump concept in a commercial building. ($4,200)
Refrigeration Systems	Continue generic research on heat and mass transfer in ground-coupled heat exchangers, composition control for nonazeotropic refrigeration, novel appliance insulation concepts, and commercial building equipment. ($2,400)	Continue generic research on heat and mass transfer in ground-coupling focusing on validation and development of design guidelines. Continue research on nonazeotropic mixtures including proof-of-concept of capacity control concepts. Continue generic research on heat pump dynamic losses, novel appliance insulation concepts and dynamic response of commercial building equipment. ($2,300)
Combustion Heating Equipment	Extend research on condensing heat exchanger materials to include nonmetallics and novel concepts. Perform life-cycle performance correlations for condensing heat exchangers. Continue research on combustion diagnostics and protocols	Continue research on nonmetallic materials and novel concepts for condensing heat exchangers. Continue research on laboratory and field life performance correlations, and expand condensing heat exchanger research

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Combustion Heating Equipment (Cont'd)	for solid fuel (wood, coal) combustion; develop chemical model for wood combustion. ($797)	to include composites. Continue development of chemical model for wood combustion and associated diagnostic techniques. ($700)
Light Sources	Continue research in plasma discharge phenomena, including Zeeman effect, mercury isotope enrichment and novel plasma gases. Initiate research into combined effects (e.g. Zeeman effect on isotopically enriched gas mixtures) of efficient discharge phenomena. Investigate the feasibility of electrodeless gigahertz fluorescent lamp operation. Continue developing advanced diagnostic techniques to characterize the plasma. Identify and characterize efficient lighting system components interaction. ($1,400)	Conduct research on advanced, electrodeless high frequency fluorescent light sources using novel gas mixtures. Continue diagnostic research to characterize the discharge plasma phenomena. Investigate interactive effects of advanced lighting system components and initiate development of advance design protocol. Evaluate Zeeman effect on isotopically enriched lamps. ($1,400)
Equipment Integration	Continue research to construct and validate model of dynamic interactions of residential forced air distribution systems; analyze loss mechanisms and develop zoning and balancing strategies to reduce energy use. Develop data base to identify loss mechanisms in distribution systems. Continue research on HVAC/lighting interaction. ($900)	Continue research in building/heating - cooling dynamic systems interactions and extend the research to include radiant and convective heat distribution techniques; complete data base development to identify loss mechanisms. Evaluate effects of electric lighting on performance of visual display terminal operators. ($800)
Subprogram Total	$9,997	$9,400

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
APPLIANCE STANDARDS		
Test Procedures	Continue to conduct ongoing program to develop, maintain, simplify and improve test procedures for appliances in support of the FTC appliance labeling program. Process manufacturer requests for modification of appliance test procedures. ($882)	Continue to conduct ongoing program to develop, maintain, simplify and improve test procedures for appliances in support of the FTC appliance labeling program. Process manufacturer requests for modification of appliance test procedures. ($900)
Consumer Education	Perform research in conjunction with FTC and others on ways to assure maximum use of efficiency and cost-of-operation data. ($98)	Develop and disseminate materials in conjunction with FTC and others to assure maximum use of efficiency and cost-of-operation data. ($100)
Appliance Standards Development	Perform research on impacts of appliance standards (including energy use analysis), complete standards rulemaking for four categories of appliances, initiate standards rulemaking for three categories of appliances, and evaluate standards analysis models. Process State requests not to be preempted by Federal appliance standards. ($1,470)	Continue research on impacts of appliance standards, complete standards rulemaking for three categories of appliances, and evaluate alternative analytic techniques (including manufacturer and consumer impacts). Process State requests not to be preempted by Federal appliance standards. ($1,000)
Subprogram Total	$2,450	$2,000

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
ANALYSIS AND TECHNOLOGY TRANSFER		
IEA Support	Provide assistance to support IEA implementing agreements, transfer results to U.S. private sector, and arrange U.S. private sector participation in IEA activities. ($200)	Continue to provide assistance to support IEA implementing agreements, transfer results to U.S. private sector, and arrange private sector participation in IEA activities. ($100)
Technical Assessment and Analysis	Obtain data on energy use and effectiveness of new technologies. Improve and maintain analytical tools and conduct analysis of current and proposed BCS programs. Monitor research results and disseminate to States, communities, other agencies, utilities, and the private sector. Work with associations and other organizations to sponsor workshops, conferences, symposiums, and committees to effectively and quickly transfer BCS research results. ($780)	Continue to obtain data on energy use and effectiveness of new technologies; to improve and maintain analytical tools and conduct analysis of current and proposed BCS programs; to monitor research results and disseminate to States, communities, other agencies, utilities, and the private sector; and to work with associations and other organizations to sponsor workshops, conferences, symposiums, and committees to effectively and quickly transfer BCS research results. ($800)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Utility Applications	None. ($0)	Initiate a program to encourage voluntary promulgation of conservation programs by utilities through demonstrating benefits of conservation in relation to activities of interest to utilities (such as load management). ($400)
Consumer Decision Research	None. ($)	Initiate consumer decision research to determine the circumstances under which consumers will be responsive to energy-saving technologies, technology transfer programs, and information programs such as audits, labels, and consumer guidelines. ($400)
Rural Housing Act Study	Rural Housing Amendments (RHA) Act Study: Initiate RHA Act of 1983 study. Prepare detailed work plan. Characterize, as required by statute, Department of Agriculture (DOA) and Department of Housing and Urban Development (HUD) residential and manufactured housing standards. (Planning carried out by in-house staff.)	Complete RHA study as required by statute including comparison of construction costs, energy use, and projected value of energy saved of manufactured homes built to national manufactured housing safety standards, with other homes eligible for loans or insurance under HUD's Title I and Title II programs, and FmHA's Title V program. ($700)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Research Utilization	Funded under the Building Systems subprogram in FY 1985.	Continue the Institutes for Architectural and Engineering Faculties and the architectural student design competition. Continue development of design tools, techniques and specific informational packages for architects, engineers, builders, owners, manufacturers, and professional school faculties. ($500)
Energy Efficient Building Center	None. ($)	Design and plan the Energy Efficient Buildings Centers and Clearinghouse System. ($100)
Fellowship Program	None	Establish a fellowship program to support the study and research of university faculty members and private sector researchers at national laboratories. ($400)
Subprogram Totals	$980	$3,400

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
FEDERAL ENERGY MANAGEMENT PROGRAM		
Federal Planning	Update the 10-Year Buildings Plan to incorporate newly-issued energy standards for new buildings; update guidelines for energy emergency plans for Federal agencies. Review changes in buildings and operations plans. Review and update the FEMP energy information systems. Continue shared savings information center. ($100)	Provide technical guidance to Federal agencies for implementing updated 10-Year Plan with new building standards. Review changes in agencies' buildings, operations, and contingency plans. Review and update the FEMP energy information systems. Prepare plans to broaden shared savings information center to other innovative financing concepts. ($200)
Federal Reporting	Prepare annual reports to the President and to Congress on the status of the Federal agencies' progress in meeting the mandated goals of EPCA, NEPCA, Executive Orders (E.O.), etc. ($100)	Prepare annual reports to the President and to Congress on the status of the Federal agencies' progress in meeting the mandated goals of EPCA, NECPA, E.O. 12003, etc. ($100)
Program Performance Evaluation	Monitor agencies' energy usage and evaluate their progress in meeting mandated goals. Analyze agency energy consumption data and develop information for use by top management. Review energy programs and projects at operational sites. ($300)	Monitor agencies' energy usage and evaluate their progress in meeting mandated goals. Analyze agency energy consumption data and develop trend line data for use by top management. Review energy programs and projects at operational sites. ($300)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
KEY ACTIVITY SUMMARY
BUILDINGS AND COMMUNITY SYSTEMS

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Program Technical Guidance and Assistance	Update life-cycle cost factors and provide changes to manual. Evaluate the use of marginal costs in selecting retrofit projects. Continue assistance to agencies in implementing cost-sharing projects. Continue workshops and seminars for life-cycle costs, "Energy in Design," and employee awareness. Prepare case studies of successful retrofit projects. Revise "How to" manuals. Increase the technology transfer programs. ($774)	Update life-cycle cost factors and provide changes to manual. Continue assistance to agencies in implementing shared-savings projects and validate data developed on shared-savings projects. Continue workshops and seminars for life-cycle costs, "Energy in Design," and employee awareness. Conduct technology transfer projects. Provide technical assistance to agencies to implement the mandatory energy conservation standards for new buildings. ($900)
Subprogram Total	$1,274	$1,500
Capital Equipment	Establish Roof Testing Center at ORNL. Replace outmoded equipment and acquire needed additional equipment at the national laboratories. ($1,225)	Continue to build and equip the Roof Testing Center at ORNL. Acquire diagnistic computer data logging, and laboratory test equipment to support indoor air quality, advanced lighting, heat pump, district heating and cooling, and FEMP programs. ($2,200)
Program Direction	Staffing at the level of 71 FTE's. Salaries, benefits, and travel to manage BCS programs. ($2,871)	Staffing at the level of 56 FTE's. Salaries, benefits, travel, and contractor support to manage BCS programs. ($3,500)
Program Total	$41,338*	$37,300

*Includes $980,000 appropriated for Urban Waste

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
ENERGY CONSERVATION
INDUSTRIAL ENERGY CONSERVATION

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1984 Approp.	FY 1985 Approp.	FY 1986 Base	FY 1986** Request
INDUSTRIAL ENERGY CONSERVATION				
Waste Energy Reduction	$11,805	$11,859	$11,859	$12,256
Industrial Process Effic.	14,200	9,556	9,556	13,500
Industrial Cogeneration	4,000	4,116	4,116	4,700
Implementation & Deployment	1,900	2,450	2,450	3,200
Program Direction	1,612	1,788*	1,788	1,844
Total				
Operating Expenses	33,517	29,769	29,769	35,500
Capital Equipment	0	2,156	2,156	0
Industrial Energy Conservation	$33,517	$31,925	$31,925	$35,500
Staffing Total FTE's	32	35	35	32

AUTHORIZATION: P.L. 93-577, "Federal Non-Nuclear Energy Research and Development Act of 1974"
P.L. 95-619, "National Energy Conservation Policy Act"
P.L. 94-163, "Energy Policy and Conservation Act"
P.L. 93-438, "Energy Reorganization Act"
P.L. 95-91, "Department of Energy Reorganization Act"

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*Reflects savings of $19,000 for Section 2901 of the Deficit Reduction Act of 1984 (P.L. 98-369).

**The FY 1986 amounts do not reflect a reduction of $3,300,000 for prior year deobligation management initiative savings.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
INDUSTRIAL ENERGY CONSERVATION
(In Thousands of Dollars)

FY 1985 Conference Mark Less 2901 Rescission	$31,925
Built In Program Increases and Decreases:	
Waste Energy Reduction	
- Reduced Effort on Improved Combustion Efficiency	-300
- Reduced Slagging Burner	-300
- Reduced High Temperature Recuperators	-159
- Increased Industrial Heat Pumps	+500
- Reduced Effort on CO_2 Utilization	-700
- Increased Effort on Waste Utilization	+200
- Increased Program Support	+1,156
Industrial Process Efficiency	
- Increased Thin Strip Casting Research	+3,350
- Decreased Electrode Materials R&D	-300
- Increased Coatings Research	+200
- Decreased Sensors & Controls R&D	+194
- Increased Effort in Separations	+500
Industrial Cogeneration	
- Increased Effort for Externally Fired Brayton	+884
- Decreased Effort on Direct Conversion R&D	-500
- Increased Effort on Bottoming Cycles	+200
Implementation and Deployment	
- Increased Technology Transfer	+650
- Increases in Industrial Reporting Program	+100
Program Direction	
- 5% Pay Cut Reduction	-83
- 2901 Rescission	-19
- Price Out of Staffing	+158
Capital Equipment	
- Decreased Request for Equipment	-2,156
Departmental Request	$35,500

Program Objectives and Strategy:

The industrial energy conservation program seeks to increase energy use efficiency and to promote the substitution of alternative fuels for conventional fuels in the industrial sector via a program of carefully targeted technology research and development activities. The program is focused on high risk development which private industry has insufficient incentive to pursue independently. Most of the activities are conducted by private institutions operating under cost-shared contracts or cooperative agreements with the Department. The industrial energy conservation program is aimed at providing: cost effective technology options that are available to industry for reducing energy losses embodied in waste streams, waste materials and inefficient processes; technologies which can utilize more abundant fuels such as coal; and the transfer of the technical information to industry for the rapid deployment of the developed technologies.

The program consists of over 190 ongoing projects in various stages of research and development addressing the highest priority energy conservation technology needs of industry which are not likely to be pursued by the private sector alone. As with any research activity the program is dynamic in the sense that it is constantly changing as the results from completed research phases is assessed. The strategy and activity focus of the program will remain constant.

Examples of research and development activities being pursued include:

- Large scale industrial heat pumps that can economically upgrade waste heat to useful process steam.
- High temperature recuperators that can operate in dirty and corrosive waste streams at temperatures up to 2600°F.
- Development of coal-fired equipment that can be retrofitted into existing oil-fired industrial furnaces and boilers.
- Research and development of cost effective technologies which will make the conversion and/or retrieval of materials from waste streams practical and attractive to industry.
- Advanced sensors and control systems to enable more precise control of energy-intensive processes.
- Electrode materials research to improve the operating efficiency of electrolytic cells.
- Direct casting of thin steel strip to eliminate energy-intensive reheating and rolling operations.
- Research and development of separation systems, including membranes, to economically and efficiently replace energy inefficient processes.
- Effective means of communicating with the industrial sector for the rapid transfer of technology research and development.

Accomplishments for FY 1984 and Anticipated Accomplishments for FY 1985:

- Spiral-wound O_2 enrichment systems were successfully tested producing a product gas enriched about 32 percent.
- A host site will be identified for the combined cycle mechanical heat pump and testing will begin in a cooperative effort with EPRI.
- Tests of two advanced large passage recuperators will begin. One is a ceramic bayonet tube configuration and one is a ceramic/metallic hybrid. Both utilized materials based on results of ceramic tests from ORNL.
- An advanced air/fuel ratio control project which was completed in FY 1983 was tested on a boiler at MIT using all private funding.
- A contract was negotiated for laboratory development and pilot plant testing of a process for direct casting of thin steel strip. A second research and development effort will be continued.
- The test phase of the low speed diesel cogeneration system was completed. This system started successful operations in late 1982 at a pharmaceutical plant. This single system installation saves 1.5 trillion Btu's annually and 4 additional installations are being negotiated without Federal involvement.
- Fluidized bed air heater tests will be initiated for the externally fired Brayton cogeneration system.
- Tests will be completed at an industrial site for the six-diode thermionic burner.
- Research will be completed on in-forest drying of wood waste and a cost-shared test phase will begin.
- Testing will be completed on a unique air-fuel ratio control at a Potomac Electric utility plant boiler. The development was sponsored by DOE; the testing is funded by EPRI.

- Small scale combustion tests will be completed for power plant CO_2 generation and recovery and a larger size test phase will begin.
- The preliminary design will be completed for a chlorine cell using thermionic diodes.
- An on-line pulp consistency sensor and a black liquor recovery boiler combustion control sensor will be completed and results will be transferred to the private sector.

Budget Request:

The Office of Industrial Programs' FY 1986 Congressional Budget is $35,500,000 which is $3,575,000 more than the FY 1985 appropriation.

Five subprograms of the industrial energy conservation program encompassing specific objectives and strategies to meet the overall industrial program objectives are:

- Waste Energy Reduction
- Industrial Process Efficiency
- Industrial Cogeneration
- Implementation and Deployment
- Program Direction

In the following sections each of these subprograms is discussed in detail including the activities estimated to be carried out with the requested budget level. Although this is the current plan for the activities within the subprograms there could be variations from project-to-project based on the findings of subsequent research stages.

	FY 1984	FY 1985	FY 1986 Request
Waste Energy Reduction:	$11,805,000	$11,859,000	$12,256,000

The FY 1986 Congressional Budget Request is $12,256,000. This is $397,000 more than the FY 1985 appropriation. The goal of Waste Energy Reduction is to conduct research and to develop energy efficient technologies to recover energy contained in industrial waste streams and waste materials, and to more efficiently utilize the energy content of fuels. The research is addressed within three distinct areas: waste heat recovery, combustion efficiency, and industrial waste utilization. National laboratory management and analytical support for all of the industrial energy conservation program is included in this subprogram.

Combustion Efficiency: Combustion efficiencies range up to about 80 percent depending on process and system design and there is a need for technology which enhances the fuel flexibility of industrial systems.

Oxygen enrichment activities in FY 1984 include fabrication and laboratory testing of an engineering model with a spiral wound, thin membrane film to produce oxygen-enriched combustion air, and another engineering unit using a hollow fiber/membrane concept. A hollow fiber unit will be tested in FY 1985 in an industrial environment. FY 1986 funds will be used to continue research on oxygen-enriched air, high-temperature combustion air, combustion of low-energy fuels, and improved combustion heat transfer. Combustion controls research continued in FY 1985 will continue in FY 1986, and will include a study of additives to enhance heat transfer, reduce emissions, and improve fuel-air mixing.

Advanced slagging coal burner development activity in FY 1985 will include system interaction testing of two prototype combustors jointly funded with Fossil Energy. These are two of eight contracts jointly funded with Fossil Energy directed at coal combustion. In addition, market analyses will assess the use of various coal types and environmental acceptability. The other six contracts on innovative burner concepts will be completed. In FY 1986 development components will be fabricated for the most promising concepts on high temperature, low pollution burners for preheated and oxygen-enriched combustion air.

Waste Heat Recovery: This activity area is intended to establish a strong technology base to address current deficiencies which prohibit timely development of ceramic heat recuperators and heat pump technology for a wide range of industrial waste heat sources. Current heat recuperator technology cannot be effectively applied without severe degradation in performance or high cost penalties to an estimated 2 quads of thermal energy wasted with corrosive and potentially fouling high temperature exhaust streams. Data is needed to solve problems and limitations of present technology. Similarly, development of new heat pump technology is needed to allow upgrading of an estimated 3.0 quads of process liquid and gas waste heat streams in the range of 140-250^{o}F up to a more useful temperature level.

Designs and materials for new fluid bed distributor plates for high temperature recuperation were evaluated, and small scale modules were tested in FY 1984. Full scale distributor plates will be fabricated and field-tested in FY 1985. FY 1986 funding will complete the evaluation of the ceramic plates in severe-environmental use.

High temperature ceramic recuperator materials development, component fabrication methods development, and non-destructive evaluation will be continued, and heat exchanger test module fabrication will be initiated in FY 1985. In FY 1986, work will continue on development of non-destructiveand mechanical test methods for ceramic recuperator components in severe environments, and methods will be developed to characterize high temperature, dirty waste streams.

Advanced heat exchangers will be fabricated and tested in these waste streams, and development of complex ceramic shape fabrication methods will continue.

Engineering system concepts and design studies for various types of heat pump systems will be completed in FY 1985 and in FY 1986. In FY 1985 selected components for advanced heat pump systems will be fabricated and tested and a study of heat pump applications in the industrial sector will be initiated with an A&E firm to develop engineering specifications for integrated systems. In FY 1986 heat pump component testing will be completed. Also in FY 1986 detail designs of the most promising heat pump systems will be made and engineering models will be built and tested. Performance of these units will be evaluated against predicted performance. Major variations in performance will be analyzed for causes and components redesigned and modified accordingly to achieve predicted performance.

Industrial Waste Utilization: A variety of solid and fluid waste streams presenting serious environmental problems for industry could be economically recycled or converted into useful fuels or energy-intensive products, if suitable specialized technology existed. Innovative mechanical, biochemical and thermo-chemical processes for converting solid and liquid wastes into fuels and feedstocks, and for recovering and recycling organics, inorganics, fibers, used oils, and metals, are needed to foster the development of substantial new private industrial activity in this area.

In FY 1984 and FY 1985, biological conversion research includes construction of a prototype high rate anaerobic reactor and laboratory testing to verify its performance characteristics. Development will be initiated on improved and waste-specific biostrains. FY 1986 funds will be used to conduct high rate reactor tests on field-supplied, low solids content wastes, to investigate plasma pyrolysis of high solids content liquid wastes, to continue improved biostrain development, and to investigate the feasibility of biological conversion of waste carbon monoxide to chemicals.

The laboratory test program to produce diesel fuel from cellulosic wastes will be continued in FY 1986 to support experimental runs on a pilot scale engineering test facility to be designed in FY 1984 and FY 1985. This facility will be designed with Federal funds and planned to be constructed with private funds. FY 1986 is planned to be the final year for Federal funds. Laboratory testing will continue in FY 1986 on mechanical compression drying of wood residues, a program initiated in FY 1984.

Laboratory investigation of large scale CO_2 generation and recovery from combustion products was begun in FY 1984 and will be completed in FY 1985, including an assessment of benefits of application to electric utility plants and large industrial power plants. FY 1986 funds will be used to analyze potential sites for cost-shared field tests of CO_2 recovery and use.

Laboratory and Analytical Support: National laboratories provide significant support to Headquarters staff in managing the activities of the total industrial program and to perform technical analyses as required. The Idaho National Engineering Laboratory, Argonne National Laboratory, Pacific Northwest Laboratory and the Oak Ridge National Laboratory are the principal participants in providing this support. Most of the management support is performed by Idaho National Laboratory which, through the Idaho Operations Office, evaluates proposals, monitors about 70 projects, prepares RFP's and conducts special studies as required. In addition analytical support is provided directly to Headquarters staff by selected contractors.

	FY 1984	FY 1985	FY 1986 Request
Industrial Process Efficiency:	$14,200,000	$9,556,000	$13,500,000

The FY 1986 Congressional Budget Request is $13,500,000. This is $3,944,000 more than the FY 1985 appropriation. The Industrial Process Efficiency subprogram supports activities which reduce the technical and/or economic risks which prevent industry from investing in more energy-efficient processes, technologies and practices. It cost-shares research and development activity which industry would not undertake on its own for a variety of reasons.

The technical issues addressed vary significantly among projects. They include, for example, such matters as understanding basic chemical reactions; the investigation and specification of materials properties; integration and testing of advanced microprocessor, laser and other technologies to improve the measurement and control of process variables; and designing, engineering and testing of more energy efficient process technologies.

Activities in the FY 1986 Request include projects in Process electrolysis; Materials processing; Sensors and controls; Separation systems and Coatings and adhesives.

Process Electrolysis: Products such as aluminum, magnesium, chromium, manganese and chlor-alkali are manufactured using energy intensive electrolytic reduction processes. Electrolysis requires more than 2.5 quads of energy annually to reduce aluminum and magnesium, and to produce chlor-alkali. The energy use efficiencies are typically less than 50 percent. The industries potentially affected have been adverse to spending significant amounts of limited capital on intensified research and development activity to reduce energy consumption. The aluminum industry, in particular, has proposed that the DOE share the developmental costs for technologies which could reduce the electrical requirements from 7.0 to 5.5 kwh per pound.

A more permanent, chemically inert anode is being designed, developed, fabricated and laboratory tested to replace the petroleum based carbon anode. An inert anode with satisfactory electrical conductivity and resistance to both high temperatures and the cryolite bath, would permit the anode-cathode gap in the aluminum reduction process to be reduced resulting in higher energy efficiency and a more stable steady state operation, thus increasing productivity. FY 1986 funding will support completion of tests under varying conditions, to identify the impact of selected variables on anode performance.

New cathodes could provide a wettable surface to aluminum. By forming a very thin, even and non-surging coating of aluminum on the surface of the cathode, the anode-cathode spacing can be further reduced. Selected materials are being tested for corrosion resistance to both alumina and cryolite, and high melting points enable them to withstand the elevated temperatures generated in the cell. Titanium diboride materials have been tested to date. Utilizing the experience gained to date and the laboratory equipment which has been developed, materials with varying compositions will continue to be tested.

Materials Processing: The FY 1986 budget request will support continuation of work commenced in FY 1983 on the thin strip casting of steel. This project is directed toward research, development and testing of the technology necessary for direct casting of thin (i.e., 0.05 inch) strip steel. Attainment of this goal would substantially increase the productivity of producing metal strip. Present methods for producing thin steel strip involve ingot or slab production. These are susequently re-heated to a plastic state and put through a rolling mill to produce strip steel which has a wide variety of applications. Direct production of the thin strip from molten steel would eliminate the necessity for ingot or slab production and subsequent re-heating prior to rolling.

Sensors and Controls: Industrial process efficiency can be considerably enhanced through utilization of automatic control systems. A major limitation on the use of such systems is the lack of appropriate sensors and systems which will operate in the environmental extremes of many industrial processes. Development will be completed and on-site tests conducted on an elevated temperature, anti-fouling humidity sensor for industrial applications.

Separation Systems: A critical and energy intensive step in many industrial processes is the separation/concentration of one or more chemical components in a solution or mixture. Typically the operation is effected through thermal evaporation or distillation. These unit operations are usually the most energy-consuming on any manufacturing site. Alternative technologies can be used to perform the required operations which may be intrinsically less energy-intensive. Such methods include application of artificially induced gravity fields; membrane separations; freeze concentration; solvent extraction; critical fluid extraction; advanced drying concepts and others. Engineering development and process research work is required to apply advanced technologies to the separation/concentration processes in many industries.

Estimates place annual industrial energy consumption for evaporation and distillation alone at 2.6 quads. In addition, large amounts of heat are also lost in contaminated hot process wastewater solutions because no adequate separation technology is available. Large quantities of energy are used to remove water from process streams, and large amounts of it are lost in contaminated hot process wastewater solutions, for the same reason. The highly specialized technologies required to reduce this energy consumption have applications in many industries, no one of which has the incentives and/or capital to perform the work on its own. Further, much of the innovative work is being conducted by small engineering companies and universities which do not have the research funds to devote to these applications.

With FY 1986 funds, several projects will be continued or initiated in this activity area. The work to be accomplished includes continuation of tests on freeze concentration processes, continuation of bench and sidestream tests on petrochemical separations and other organic separations using new membrane technologies, and research on improved understanding of basic chemical and physical phenomena affecting energy required for separations.

Coatings and Adhesives: A critical need exists for development of surface coatings to operate in corrosive environments, enabling process flexibility and increased opportunities for waste heat recovery. Amorphous metallic alloys have shown very high corrosion resistance, which is attributed to formation of a uniform passive layer when exposed to corrosive conditions. The two types of corrosion-resistant amorphous metallic alloys are metal: metalloid alloys and refractory transition metal alloys. Techniques for depositing both types of alloys on substrates have been developed to provide coatings approaching free alloy corrosion-resistance. Testing will continue on amorphous metallic coatings for adhesion, stability and corrosion resistance. Test specimens will be coated for exposure testing in an industrial environment.

	FY 1984	FY 1985	FY 1986 Request
Industrial Cogeneration:	$4,000,000	$4,116,000	$4,700,000

The FY 1986 Congressional Budget Request is $4,700,000. This is $584,000 more than FY 1985 appropriation. The goal of Industrial Cogeneration is to encourage research on improved energy conversion systems to meet various industrial cogeneration requirements including systems with high electrical to thermal output ratios; advanced low voltage, high current direct conversion devices; charâcterization of organic Rankine cycle working fluids; and bottoming cycle component development and evaluation.

Advanced Topping Cycle Systems: Increased use of industrial cogeneration can be fostered through development of higher electrical-to-thermal output ratio systems than are yielded by standard steam turbine concepts. Based on recent studies a potential expansion to 42,000 mw of cogenerated electricity is possible with existing technology and this could be further expanded to 60,000 mw with the development of new cogeneration technologies.

In FY 1984, a topping combustor test stand for the externally fired Brayton system was designed and fabricated, and natural gas performance tests were initiated. The natural gas topping tests will be completed in FY 1985, and use of a new design coal combustor will be evaluated. FY 1986 funds will be used to conduct coal combustor topping tests on the externally fired Brayton system, to conduct a ducting engineering study for the system, to develop a computer model on controls simulation, to conduct laboratory tests using waste fuels, and to perform a design study of a low temperature (1400°F) gas turbine system. This is an externally-fired Brayton system without the additional cost of a topping combustor. -

Testing was initiated in FY 1984 for a slurry-fired diesel system using a single-cylinder test engine. In FY 1985 the testing will be completed and design studies will begin on a full scale engineering test facility engine for long term slurry tests, and associated component development and testing will be initiated. FY 1986 funds will complete the development and testing of selected components and will complete a design study of site-specific requirements for the installation.

Conversion of Thermal Energy to D.C. Electricity: Direct conversion devices, such as the thermionic diode on alkali metal electrode cells, may be able to cost-effectively meet some of industry's 5,000 megawatt requirement for relatively low voltage d.c. power used in electrolytic cells and other processes.

In FY 1984, design of a thermionic array to power a single full-size chlor-alkali electrolytic cell was initiated. This thermionic array will be fabricated and functionally tested in FY 1985. In FY 1986, a host site will be selected for proof-of-concept testing of the thermionic diode array on a chlor-alkali cell, and site-specific design requirements will be established. In addition, design and fabrication of a 1,000 watt sodium heat engine laboratory unit will be accomplished with the FY 1986 budget request.

Bottoming Cycles Development: Increased performance of the low temperature waste heat driven organic Rankine cycle could be achieved through the development of tailored organic fluids. Bottoming cycle cogeneration systems operating in the 700^{O}F and higher temperature range would achieve widespread use were they developed to be economically available.

In FY 1986, performance evaluation of a small composite material BiPhase separator, initiated in FY 1984, will be completed. In addition, laboratory testing of six selected ORC working fluids and components will be continued. Evaluation of these ORC fluids under realistic operating conditions will determine their limitations and permit modification or "tailoring" of the organic fluids to overcome these limitations for use in improved Organic Rankine systems.

	FY 1984	FY 1985	FY 1986 Request
Implementation and Deployment:	$1,900,000	$2,450,000	$3,200,000

The FY 1986 Congressional Budget Request is $3,200,000. This is $750,000 more than the FY 1985 appropriation. The Implementation and Deployment program is characterized by a cooperative effort between government and industry to enhance industry awareness about the necessity of energy efficiency improvements, and the cost effectiveness of investment in energy conservation. For a variety of reasons, an information gap often exists between the source of a technology and potential users. Significant energy savings are achievable if these gaps can be closed through an effective program of technology and information transfer.

The FY 1986 Request includes activities in Workshops and seminars, Publications, Energy audits for small and medium manufacturing facilities, and the Industrial Efficiency Reporting Program.

Workshops and Seminars: This activity provides cooperative support in the conduct of workshops, seminars, and technical symposia on industrial energy conservation. Support may be provided for events both initiated and cosponsored by the DOE. Representative activities receiving past support have been the Industrial Energy Conservation Technology Conference and Exhibition held by the Texas Industrial Commission, and the World Engineering Conference held annually by the Association of Energy Engineers. Additional activities will be conducted as opportunities arise, having as their objective more effective technology transfer and improved energy productivity. Cooperative presentations will be made, on both specific technologies and general process improvements, with the major industrial trade associations and, as appropriate, national engineering and professional societies.

In FY 1986 support for selected industry, association and professional society conferences will continue. Targeted industry workshops and seminars will be increased, with particular focus on technologies which have been developed with DOE support. These seminars will be developed and implemented with the assistance of credible industrial associations and professional organizations. Attendees will be manufacturers and equipment producers who are in a position to make decisions which directly influence energy efficiency.

Publications: Information publication and dissemination are important elements of technology transfer. Publications concerning new and underutilized energy efficient technologies, with particular emphasis on those which have been developed with the assistance of the DOE, are produced and distributed under the auspices of this activity. These publications cover not only specific technologies but also address overall energy management for major industrial sectors.

With FY 1986 funds, development, review and publication of written materials, which provide information on projects sponsored by the DOE, will be performed. The specific publications will be determined by the status of individual projects and the nature of the intended audience. In general, publications will be produced with close cooperation and guidance from industrial associations, manufacturing corporations and/or professional engineering societies. In addition, the Industrial Communications Data Base, used for targeted mailings of information, will be updated and utilized.

Energy Analysis and Diagnostic Centers: The Energy Analysis and Diagnostic Center (EADC) program provides energy management assistance to small and medium-size manufacturers. This program has provided technological assistance and economic evaluations in the plants of over 700 manufacturers in seven states. This project provides small enterprises with the expertise necessary to identify significant cost-effective energy savings. An important additional benefit of the project is the training afforded student engineers in energy conservation.

The EADC program has been operational since 1977. It is anticipated that the project will continue at an expanded level during the FY 1986 period, with operation of 12 EADC's. In addition, steps will be taken to use EADC results to increase private sector initiatives directed at conducting energy audits of small and medium-size manufacturing facilities.

Industrial Energy Efficiency Improvement Reporting: The Industrial Energy Efficiency Improvement Reporting Program receives data on industrial energy efficiency improvement and recovered materials utilization. Corporations in SIC's 20-39 consuming in excess of one trillion Btu's per year report energy consumption, fuel switching and recovered materials utilization to the Department of Energy. This reporting program is mandated by the Energy Policy and Conservation Act (P.L. 94-163), as amended by the National Energy Conservation Policy Act (P.L. 95-619). The information, as summarized by DOE and the various industry associations involved in the program, is widely utilized and referenced within industry. The Annual Report to the Congress and the President for the 1984 period will be produced and issued.

	FY 1984	FY 1985	FY 1986 Request
Program Direction:	$1,612,000	$1,788,000	$1,844,000

The FY 1986 Congressional Budget Request is $56,000 more than the FY 1985 appropriation. The request of $1,844,000 is for 32 full-time equivalent positions for conducting the program. There has been a shift of responsibility in project management to the National Laboratories leaving Headquarters personnel with more time to perform program planning, budgeting, procurements and program control as well as management of a number of key projects.

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Waste Energy Reduction
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
Improved Combustion Efficiency Objective: To increase overall efficiency of combustion through increased flame temperature, decreased excess air, and higher combustion air preheat.	Conduct proof-of-principle testing of hollow fiber prototype units in an industrial environment and evaluate results. Prepare reports on findings including an economic assessment of the technology. ($500)	Continue research in oxygen enriched air, high temperature combustion air, low energy fuels and improved heat transfer. ($200)
	Initiate research in appropriate combustion control areas based on a state-of-the-art assessment of the technology. ($300)	Continue to develop and evaluate techniques for burner controls and instrumentation; evaluate additives to increase heat transfer, reduce emissions and improve fuel/air mixing. ($300)

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Waste Energy Reduction
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
Advanced Slagging Coal Burner Objective: Develop coal-fired equipment that will retrofit existing oil-fired boilers without baghouses. (Joint project with Fossil Energy)	Conduct system interaction testing of the two 50 MMBTU/HR prototype combustors to obtain performance characterization, environmental effects, and fuel evaluation (coal types). Conduct market analyses including coal type utilization, and environmental and customer acceptance assessments. Continue research on six additional innovative combustion concepts. ($900)	Continue bench scale testing of selected innovative burner concepts: low NO_x burners, burners which operate at very high temperature preheated air. ($600)
Advanced High Temperature Recuperators Objective: To develop high effectiveness heat exchangers that operate in various environments and can be produced at relatively low cost.	Fabricate full size fluid bed distributor plates and conduct field tests to obtain performance data. ($300)	Complete testing and evaluation of fluid bed ceramic distributor plates in severe environments. ($300)

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Waste Energy Reduction
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
Advanced High Temperature Recuperators (Cont'd)	Continue ceramic materials development to produce high quality, low cost ceramic powders. Develop technology to fabricate complex ceramic shapes and to perform non-destructive evaluation of fabricated parts for flaw detection and service life prediction. Select designs of advanced heat exchanger concepts and initiate fabrication of test modules for testing in severe environments. ($1,859)	Continue development of non-destructive test methods and service life prediction methods for ceramic heat exchanger components operating in severe environments. Continue to develop waste stream characterization methods for high temperature dirty waste streams and conduct preliminary characterization of a selected stream. Fabricate selected advanced heat exchangers and evaluate operation in dirty, high temperature streams. Continue development of technology to produce low cost ceramic powders and fabricate complex ceramic heat exchanger shapes in a cost effective manner. ($1,700)

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Waste Energy Reduction
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
Advanced High Temperature Industrial Heat Pumps Objective: To upgrade low temperature waste heat to produce process steam.	Evaluate concepts for various types of heat pump systems and evaluate components along with alternative working fluids. Conduct design studies of these concepts. Prepare preliminary designs for several systems with alternative working fluids. Evaluate expected performance of these systems with various working fluids, materials compatibility, etc. Fabricate selected systems components for bench scale testing, conduct laboratory tests, and evaluate test results against expected performance. Conduct a study of heat pump applications in the industrial sector and develop engineering specifications for integrated heat pump systems. ($3,000)	Continue evaluation of these heat pump systems and laboratory testing of engineering components. Conduct detail design studies of the most promising heat pump systems, including a reappraisal of performance and economics. Build complete laboratory models of the most promising heat pump systems, conduct laboratory performance tests on these engineering models, and evaluate performance data. Analyze variations in performance against predicted performance to determine causes. Redesign and modify components to achieve predicted performance. ($3,500)

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Waste Energy Reduction
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
Recovery of Energy Value from Liquid/ Gaseous Wastes Objective: To utilize industrial waste materials (gases, liquids) as feedstocks, fuels or other usable forms.	Design and build a prototype high rate anaerobic reactor and conduct laboratory testing to verify performance characteristics. Initiate development of improved and waste specific biostrains. ($500)	Conduct high rate reactor tests on field supplied low solids content waste feed materials. Investigate plasma pyrolysis of high solids content industrial liquid waste materials. Continue biostrain enhancement activity to improve conversion of waste to fuel. Investigate feasibility of waste CO conversion to chemicals. ($900)
Utilization of Waste CO_2 Stack Gas Objective: To utilize CO_2 waste stack gas as a product and for enhanced oil recovery.	Complete laboratory work and analysis of of CO_2 generation and recovery including benefits and economics of application to electric utility and large industrial power plants. ($1,000)	Analyze potential for cost-shared field tests. Conduct engineering and systems studies to locate potential CO_2 generation sites and use points for CO_2. ($300)

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Waste Energy Reduction
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
Forest Waste Utilization Objective: To more effectively utilize forest and agricultural residue and waste and waste as industrial fuels.	Complete the design of the pilot scale engineering test facility to produce diesel fuel from cellulosics/polymers and provide laboratory support and instrumentation for for continued process development. ($500)	Continue laboratory process development to improve yields of diesel fuel from cellulosics/polymers and support the pilot scale engineering test facility experimental runs with various feed materials. ($200)
	Conduct compression drying of wood chips and bark to remove water to the 35% moisture content level and eliminate supplemental fuel oil firing for flame stability. (By Costing Out Prior Year's Obligations)	Continue laboratory compression testing of wood residue samples under simulated operating conditions for degree of dryness obtained, operational problems encountered, etc. ($100)
National Laboratory & Analytical Support	($ 3,000)	($ 4,156)
Total: Waste Energy Reduction	$11,859	$12,256

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Industrial Cogeneration
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
Advanced Topping Cycle Systems Objective: Develop and test highly efficient cogeneration systems with high electrical output.	Complete natural gas topping combustor tests. Evaluate use of coal combustor for topping. Build or modify a test stand for conducting air heater evaluation tests. Complete fabrication of air heater test sections. ($1,516)	Conduct coal combustor topping tests. Conduct a ducting engineering study. Develop a computer model on controls simulation. Conduct laboratory tests on waste fuels. Install air heater test sections. Perform a design study of a lower temperature gas turbine. ($2,400)
	Initate a parametric design of a full scale engineering test facility diesel engine for long term testing of coal/water slurry fuels. Initiate component development and testing. ($1,000)	Complete development and testing of selected components for a steam diesel test facility engine. Complete design of site specific requirements for the test engine installation. Establish an industry interaction group to review test results and share in facility planning. ($1,000)

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Industrial Cogeneration
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
Thermal to Electrical Energy Conversion Objective: Develop systems for conversion of thermal energy to direct current.	Complete the engineering design of the chlor-alkali cell thermionic diode array and installation requirements. Initiate fabrication of the array and prepare for functional testing. ($800)	Select host site for proof-of-concept testing for the thermionic diode array on a chlori-alkali cell and complete the design for site specific requirements. ($600)
	Complete laboratory testing of 200 watt developmental sodium heat engine. Complete an engineering study of applications and economics. ($800)	Design and fabricate a 1,000 watt sodium heat engine laboratory unit. ($500)
Advanced Bottoming Cycle Systems Objective: Develop and test cogeneration systems that operate using thermal process waste energy to produce electricity.	Initiate composite materials development of BiPhase concentrator. Conduct materials testing of a model separator made of composite materials. (By Costing Out Prior Year's Obligations)	Complete performance evaluation of a composite material biphase separator component in a model test unit. ($130)

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Industrial Cogeneration
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
Advanced Bottoming Cycle System (Cont'd)	Continue Organic Rankine Cycle (ORC) working fluid evaluation. Initiate a design study and laboratory component test of ORC vaporizers. Design, build and initiate laboratory testing of a subscale (100Kw) advance prime mover for low cost high performance systems. (By Costing Out Prior Year's Obligations)	Continue laboratory testing of ORC fluids. ($70)
Total: Industrial Cogeneration	$4,116	$4,700

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Industrial Process Efficiency
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
Process Electrolysis Objective: To conserve electricity by developing systems for more efficient electrolytic reduction of metals.	Continue development and testing of new electrode materials. Characterize single crystals of potential materials. Analyze the chemistry of the Hall cell cryolite bath, and chemical reactions within the cell, with more advanced equipment. Commence metallographic analyses of materials. ($1,800)	Complete development, testing and characterization of inert anode materials. Operate aluminum reduction test cells with stable cathode materials. ($1,500)
Materials Processing Objective: Reduce energy requirements in melting, forming, rolling and fabrication of materials.	Test alternative methods for feeding molten metal. Complete concept development/evaluation, design of test facility for thin slab casting. Commence procurement of equipment for scale-up testing. Develop model for casting steel on a single wheel Apply model to develop experimental plan for critical tests. Purchase melting equipment for industry lab tests. ($4,650)	Complete testing of alternative methods for feeding molten metal, and make selection of feeding system. Continue procurement of equipment for testing the thin strip casting of steel. Commence installation of test facility. ($8,000)
Coatings and Adhesives Objective: Reduce the energy required to apply coatings and dyes to various surfaces.	Define parameters for depositing amorphous metallic coatings, conduct adhesion studies and test corrosion resistance in sulfuric acid and ferric chloride. (By Costing Out Prior Year's Obligations)	Complete testing of amorphous metallic coating for adhesion, stability and corrosion resistance. Coat test specimens for exposure testing in an industrial environment. ($200)

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Industrial Process Efficiency
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
Sensors and Controls Objective: To develop on line sensing devices to improve measurement of process parameters. Develop systems to enable more accurate and timely control of processes.	Complete research on laser-based sensor systems for determining the chemical composition of molten metal baths. Test probe designed to produce stream of fine powder from molten metals. Design and test powder transport system. Test system for rapid analysis of powder sample. Transfer of materials and designs for continuous temperature measurement of molten steel. ($1,400)	Activities shown are continued and funded by FY 1985 appropriations.
	Develop an elevated temperature anti-fouling humidity sensor for industrial applications. Conduct lab tests to determine performance against grain drying criteria. (By Costing Out Prior Year's Obligations)	Complete design, and fabricate Complete development of elevated temperature anti-fouling humidity sensor for industrial applications. Conduct on-site tests and evaluate. ($800)
	Acquire lab data on pyrolysis mass spectrometer, lignin assay and laser-based boiler inspection sensors, for design of bench-scale units. Select mills at which to conduct testing of devices. devices. ($406)	Activities shown are continued and funded by FY 1985 appropriations.

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Industrial Process Efficiency
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
Sensors and Controls (Cont'd)	Design and install advanced components and develop programs for testing hierarchical control in a pulp and paper mill. (By Costing Out Prior Year's Obligations)	Complete development testing and analysis of hierarchical control system application in an integrated pulp and paper mill. ($1,200)
Separations Research Objective: To develop more efficient technologies and equipment for accomplishing separation/concentration in a variety of industries.	Conduct research on indirect freeze concentration. Use test loop to optimize operating parameters, develop scale-up data and determine maximum concentration with sugar solutions and black liquor. Evaluate data. Continue bench scale testing of freeze process for concentration of beet sugar juice and black liquor. Conduct technical/economic assessments. ($300)	Continue lab tests of freeze processes for application to various foods and black liquor. ($400)
	Complete laboratory tests, construct and test a bench-scale unit for a membrane coupled to a brine electrolysis cell. Complete technical and economic analyses. Build and test a skid-mounted membrane unit for separating moisture from hot dryer exhaust. Complete technical and economic analyses. Construct a unit for testing membranes to separate sugars. ($400)	For advanced membrane technologies, continue tests on petrochemical organic stream separations and waste. ($800)

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Industrial Process Efficiency
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
Separations Research (Cont'd)	Continue chemical and physical analyses of solutions, elements associated with common energy-intensive separations. ($600)	Continue chemical and physical analyses of solutions, elements associated with common energy-intensive separations. ($600)
TOTAL - INDUSTRIAL PROCESS EFFICIENCY	$9,556	$13,500

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Implementation & Deployment
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
Industrial Reporting Program Objective: Carry out legislative mandate, and establish basis for joint activities with industry to improve industrial energy productivity.	Continue receipt and analysis of reports on energy efficiency improvement and recovered materials, which are required to be submitted by industry annually. Publish DOE report on industrial energy efficiency improvement. ($200)	Continue receipt and analysis of ports on energy efficiency improvement and recovered materials, which are required to be submitted by industry annually. Publish DOE annual report on industrial energy efficiency improvement. ($300)
Energy Analysis and Diagnostic Centers Objective: (1) Define energy conservation opportunities for small and medium size firms. (2) From results of completed audits, develop case studies of conservation opportunities that can be pursued by small and medium sized firms.	Continuation of program to conduct audits with 12 participating universities. Implement, with industry and utilities, ways which the EADC concept could be leveraged for wider coverage. ($1,500)	Continuation of program to conduct audits, with 12 participating universities. Evaluate program results and rotate program participation as appropriate among different schools. ($1,500)
Technology and Information Transfer: Objective: Provide information on costs and benefits to industry of implementing new technologies or practices which are more energy efficient.	Continue development, review and publication of written materials which provide information on projects sponsored by the Department of Energy.	Provide support in the conduct of workshops, seminars, and technical symposia on industrial energy conservation. Particular focus to be on technologies developed with DOE assistance.

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

Implementation & Deployment
($000)

Key Activity	Planned Activities During FY 1985	Planned Activities During FY 1986
	Support of technical meetings and symposia devoted to industrial energy use and efficiency. Conduct workshops on selected new technologies. ($750)	Develop, publish, and distribute written materials which address specific energy-saving technologies, as well as overall energy management for major industrial sectors. ($1,400)
TOTAL-IMPLEMENTATION AND DEPLOYMENT	$ 2,450	$ 3,200
PROGRAM DIRECTION	$ 1,788	$ 1,844
CAPITAL EQUIPMENT	$ 2,156	
TOTAL: INDUSTRIAL ENERGY CONSERVATION	$31,925	$35,500

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
ENERGY CONSERVATION
TRANSPORTATION

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1984 Appropriation	FY 1985 Appropriation	FY 1986 Base	FY 1986 Request
Transportation				
Vehicle propulsion R&D				
Operating expenses	$37,970	$31,852	$31,852	$20,100
Electric and hybrid vehicle R&D				
Operating expenses	11,570	8,429	8,429	6,075
Transportation systems utilization				
Operating expenses	500	1,666	1,666	1,200
Alternative fuels utilization				
Operating expenses	2,480	2,450	2,450	1,600
Advanced materials development				
Operating expenses	1,500	6,076	6,076	9,290
Program direction				
Operating expenses	1,638	1,890*	1,890	1,700
Capital equipment	0	2,940	2,940	0
High temperature materials lab.				
Operating expenses	0	0	0	310
Construction	9,000	6,469	6,469	2,700
Subtotal	9,000	6,469	6,469	3,010
Total				
Operating expenses	55,658	52,363	52,363	40,275
Capital equipment	0	2,940	2,940	0
Construction	9,000	6,469	6,469	2,700
Transportation	$64,658	$61,772	$61,772	$42,975
Total FTE	31	36	36	28

*Reflects savings of $23,000 for Section 2901 of the Deficit Reduction Act of 1984 (P.L. 98-369).

Authorization:	P.L. 93-577,	"Federal Non-nuclear Energy Research and Development Act of 1974"
	P.L. 93-275,	"Federal Energy Administration Act of 1974"
	P.L. 93-438,	"Energy Reorganization Act of 1974"
	P.L. 94-163,	"Energy Policy and Conservation Act"
	P.L. 94-413,	"Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976"
	P.L. 95-91,	"Department of Energy Organization Act"
	P.L. 95-238,	"Department of Energy Authorization for FY 1978"
	P.L. 96-512,	"Methane Transportation Research, Development and Demonstration Act of 1980"

Summary of Changes

FY 1985 Conference mark less 2901 rescission	$ 61,772
Program increases and decreases:	
Do not continue MOD II Stirling engine design and component development	- 13,701
Increase adiabatic diesel research and development	+ 1,000
Reduce development of electric vehicle batteries and propulsion systems	- 105
Complete funding of advanced vehicle technologies, e.g., nickel-cadmium batteries	- 620
Reduce integration and test of electric vehicle improvements and battery candidates	- 1,829

Program increases and decreases (cont.):

Print and distribute Gas Mileage Guide and analyze alternate formats and distribution patterns	+ 200
Do not continue DECAT and ridesharing programs	- 1,166
Conduct transportation data analysis and projections	+ 500
Do not continue with phase II of test and evaluation of methanol-powered automobiles	- 980
Expand synfuel and methane data base through R&D	+ 130
Expand R&D on structural ceramics for advanced heat engines	+ 3,214
Do not continue with acquisition of capital equipment to support advanced materials development and electric vehicle test and evaluation	- 2,940
Continue construction of High Temperature Materials Laboratory with pre-operational support	- 3,459
Transfer technological developments to industry	+ 1,149
Program Direction:	
o 5% pay cost reduction	- 75
o 2901 rescission	- 23
o Price out staffing	- 92
FY 1986 Budget Request	$ 42,975

Budget Request: The transportation FY 1986 budget request for operating expenses and construction is $42,975,000. This amount is required to carry out the program's objective to perform research and development on vehicles and engines which will increase the fuel efficiency of the transportation system and allow a switch from petroleum to electricity and alternative fuels. The strategy to achieve this objective includes emphasis on technology development rather than product design, maximum involvement by U.S. industry in identification and solution of technology problems, and concentration on key technology barriers where risks prohibit industry-only financing.

Accomplishments: Major FY 1984 program accomplishments include:

- Operated the Garrett/Ford AGT 101 automotive gas turbine engine up to 2100°F turbine inlet temperature with stationary ceramic components.
- Accumulated 85 hours of test time on the Allison/Pontiac AGT 100 automotive gas turbine engine at temperatures up to 2000°F with stationary ceramic components.
- Completed the industry evaluation of the automotive Stirling engine by General Motors Corporation and John Deere.
- Published 13 individual adiabatic diesel engine program reports on specific technology investigations including friction and wear, engine/systems analysis and models, insulation materials, and waste heat recovery.
- Completed the first generation development of the Ford Motor Co. advanced single-shaft a.c. powertrain for passenger car applications with dynamometer and in-vehicle testing.
- Completed the transfer of the dynamometer test facility from the Jet Propulsion Laboratory to the Idaho National Engineering Laboratory.
- Completed testing of the first set of product improvements of the User Task Force for the site operator electric vehicles and initiated the procurement of the second set of improvements.
- Established and published the fundamental requirements of a neat-methanol cold starting system.
- Initiated the operation of a facility at Southwest Research Institute for production of test quantities of standardized synfuels.

- Awarded the first series of research contracts under the Advanced Materials Development program including silicon carbide and silicon nitride powder development, environmental effects in toughened ceramics, ceramic matrix composite development, high-temperature fracture toughness, and studies of dynamic contact interfaces.

- Established the formal Interagency Coordinating System for Advanced Materials Development activities and initiated rotating bi-monthly meetings.

- Completed the architectural and engineering design for the High Temperature Materials Laboratory at Oak Ridge National Laboratory.

Vehicle Propulsion R&D .... $ 20,100,000

The goal of the Vehicle Propulsion R&D program is to encourage development within the transportation industry of more fuel-efficient, fuel-flexible and cost-effective transportation propulsion system options through support of research and development on technological barriers and proof of concepts.

The technical objectives of the Vehicle Propulsion R&D program are: (1) achieving at least a 30 percent improvement in fuel economy over conventional engines, (2) meeting or exceeding established emission level regulated requirements, and (3) operating satisfactorily on a variety of fuels. To accomplish these objectives, research and development has been pursued on establishing technology bases for advanced engine concepts including the automotive gas turbine, the automotive Stirling engine, and the heavy duty adiabatic (uncooled, minimum friction) diesel engine. Common to the need of all advanced engine concepts is the requirement to develop improved high-temperature materials and components.

The FY 1986 funding will allow the completion of the proof-of-concept Automotive Gas Turbine program with both contractor teams demonstrating engine operation at the 2400^0 - 2500^0F design goal with completely integrated ceramic components. Both contractor teams increased cost-sharing sufficiently during FY 1985 so that both teams will be continued with full engine development during FY 1986.

The Heavy Duty Transport Technology program will continue research activities focussed on identified technological barriers in the development by industry of an uncooled, minimum friction heavy duty diesel engine including integrated waste heat recovery with the potential for efficiency improvements in the 30 to 40 percent range. A conceptual design for a multi-cylinder, proof-of-concept heavy duty truck adiabatic diesel engine will be carried out with industry, based on the results of the technology barrier investigations, and design and fabrication of a single-cylinder test and evaluation capability will be completed.

Technology Assessment and Transfer activities will be expanded to provide an ongoing assessment of related developments by industry and other Government programs and to assure that maximum interface and cooperation is established with industry both for dissemination of research results and inputs on technology needs.

Electric and Hybrid Vehicle R&D .... $ 6,075,000

The goal of the Electric and Hybrid Vehicle program is to develop the technology, in cooperation with industry, that will lead to the production and introduction of electric vehicles into the Nation's transportation fleet. Since electricity is generated by many different sources of fuel such as coal, hydro or nuclear, the use of electric vehicles would substitute more abundant sources of energy for petroleum-based fuels.

The major emphasis of the Electric and Hybrid Vehicle program continues to be the development of battery technology for passenger car and commerical van or light truck applications. In FY 1985, lead-acid and nickel-iron battery R&D will concentrate on electrolyte and thermal management systems that will result in longer life and lower operating costs. In FY 1986, proof-of-concept complete vehicle lead-acid and nickel-iron battery systems will be delivered and tested that are expected to meet performance goals of a range of 100 miles on a single charge, battery life of 60,000 vehicle miles and acceleration and hill climbing capability better than a diesel vehicle. In FY 1985, sodium-sulfur and zinc-bromine battery development specifically focussed on the electric vehicle application was initiated in concert with an a.c. propulsion system development. The battery R&D for the electric vehicle application is closely coordinated with and based on the core technology under development for sodium-sulfur and zinc-bromine battery technology by the Energy Storage Division. In FY 1986, the emphasis of the sodium-sulfur development will be on determining the optimum cell configurations, thermal management and packaging for the electric vehicle application. The laboratory testing and evaluation of experimental batteries will continue at the Idaho National Engineering Laboratory (INEL) and the National Battery Test Laboratory (NBTL). Battery technologies scheduled for laboratory evaluation in FY 1986 include immobilized electrolyte lead-acid, improved nickel-iron, sodium-sulfur, zinc-bromine and zinc-chlorine battery systems. In addition, Phase I of the jointly funded Department of Energy/Electric Power Research Institute project is completing the construction of a prototype van test bed that is capable of testing the best available battery technology in actual fleet operational environments.

In the area of propulsion system technology, efforts will continue in FY 1986 on the dual-shaft a.c. propulsion system and the a.c. induction motor, multi-speed automatic transaxle and controller/power inverter techniques. In FY 1985, an advanced single-shaft a.c. powertrain will be completed that incorporates a unique, sealed, lightweight motor/transaxle assembly and a controller/power inverter using experimental high-current transistors. Also in FY 1985, the next generation of the promising technologies under development in the single-shaft propulsion system program will be explored. These technologies include improved permanent magnet materials that will result in light weight and lower cost traction motors as well as reducing the complexity and cost of the electronic control systems.

The Test and Evaluation activities will continue the laboratory characterization testing of improved and advanced technologies as well as the data collection and analysis of actual on-the-road electric vehicles to determine the technical and economic feasibility of these new technologies in vehicle fleet applications. In FY 1986, the program will continue to collect data and refine the data base to provide information to the R&D community and eliminate identified vehicle deficiencies. On the chassis dynamometer at INEL, newly developed powertrain components as well as the recently completed a.c. propulsion systems will be rigorously tested and evaluated. The Electric Vehicle Test Center at INEL is a unique facility for the testing and evaluation of experimental batteries and newly developed powertrain technology.

In FY 1986, technology transfer activities will include a Contractor Coordination Meeting for electric vehicle users, manufacturers and the research community to discuss current progress and future coordinated R&D efforts. Workshops on battery development, testing and maintenance training of new technologies will be conducted.

Transportation Systems Utilization .... $ 1,200,000

The goal of the Transportation Systems Utilization program is to provide information to the public concerning the fuel efficiency of new transportation vehicles and operational conservation techniques which will assist consumers in both their purchase decisions and driving habits, leading towards the reduction of petroleum usage by highway vehicles through low-cost and near-term conservation actions.

The printing and distribution of the Gas Mileage Guide will be continued in FY 1986. For Model Year 1985 approximately three million copies of the Guide were distributed to the public through 26,000 new car dealers.

Activities concerned with the collection, analysis and distribution of transportation energy utilization data, and analyses of conservation impacts under various technological options and future fuel scenarios will be continued. This information will also be utilized in the development of technology transfer plans which include integration of long-term and near-term technological, institutional and information dissemination options.

Alternative Fuels Utilization .... $ 1,600,000

The goal of the Alternative Fuels Utilization program is to encourage the use of non-petroleum-based fuels in the transportation sector by establishing a utilization-oriented data base for alternative fuels in both contemporary and advanced heat engines. The approach has been to conduct systematic investigations of the fundamentals of alternative fuel use problems in both spark-ignition and diesel engines, concentrating on nearer-term fuels first (alcohols) and expanding the data base in subsequent stages to include synthetic fuels and advanced engines.

Fuel/engine investigations will be continued in FY 1986 which will contribute to the establishment of a technical data and information base in synfuels utilization and eventually identify finished fuels that will permit reduced use of energy feedstock and more efficient resource conversion processes.

Advanced Materials Development .... $ 9,290,000

The goal of the Advanced Materials Development program is to develop an industrial technology base in structural ceramics and ceramic composites capable of providing reliable and cost-effective components for high-temperature, efficient transportation propulsion systems while eliminating requirements for scarce strategic materials.

The efficiency and economics of advanced heat engines are materials limited, and utilization of high-temperature ceramic components and coatings is a key technology need. Although ceramics have demonstrated the potential temperature and environmental resistance capabilities necessary, substantial research is required to achieve adequate strength, toughness, and other specific properties needed before reliable ceramic components can be produced commercially. The technology developed within the program, as well as the availability of the High Temperature Materials Laboratory being constructed under the program at Oak Ridge National Laboratory, will have significant spinoffs for increasing the efficiency and productivity of a wide range of other industrial applications in addition to transportation.

During FY 1986 the phased activities on existing contracts and research projects will be continued essentially in accordance with the Ceramic Technology for Advanced Heat Engines Program Plan. These work elements include ceramic powder synthesis and characterization, ceramic composites formulation and characterization, materials design methodology, data base/life prediction, and ceramics coatings/joining.

Program Direction .... $ 1,700,000

The budget request provides for 28 FTE positions to develop strategies, plans and resource requirements, and provide the integrated program management necessary to conduct the research and development of the various transportation technologies described in the budget request.

High Temperature Materials Laboratory .... $ 3,010,000

To support the advanced high-temperature materials efforts both within government and industry, construction of a High Temperature Materials Laboratory (HTML) at Oak Ridge National Laboratory was initiated in FY 1983. The HTML will provide a unique capability for high-temperature materials research which (1) makes available a broad multidisciplinary professional staff, (2) provides a common focal point for industrial/university/government participation, and (3) provides access to high-cost research equipment which would otherwise be denied many researchers. In FY 1985 the construction contract will be finalized, and site preparation, foundations and actual construction begun. Specifications for major items of research equipment will be prepared. Required funding to complete construction and equip the laboratory is included in the FY 1986 request. Building occupancy is scheduled for 1988.

In addition to construction costs, activities will be continued to establish an Industry Overview Committee, set-up user centers' operational procedures, and implement the acquisition of research equipment and research staff.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY
Transportation
VEHICLE PROPULSION R&D
(dollars in thousands)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Automotive Gas Turbine	Continue proof-of-concept automotive gas turbine engine development with two industry teams; continue integration of qualified ceramic components until final configuration is reached and characterized. ($14,681)	Complete proof-of-concept automotive gas turbine engine development with two industry teams reaching engine dynamometer testing of completely ceramized configuration. ($15,000)
Automotive Stirling Engine	Continue proof-of-concept automotive Stirling engine development. Complete a paper design of the Mod-II engine; continue technology base development. ($13,701)	Program completed in FY 1985. ($0)
Heavy Duty Transport (Adiabatic Diesel)	Continue component development stage of promising ceramic components and coatings, solid lubricants and gas bearings, and ceramic joining/interface methodology; initiate system integration investigation of single-cylinder test and evaluation capability; complete adiabatic operation system models. ($2,000)	Initiate component evaluations of developed ceramic components in single-cylinder test cell and utilize results for second stage component developments; complete design of baseline engine configuration; initiate industry design of multi-cylinder heavy duty proof-of-concept adiabatic diesel engine. ($3,000)
Technology Assessment and Transfer	Continue vehicle propulsion technology assessments in industry and government; conduct technology transfer activities, including conferences, workshops, publications, etc., to assure transfer of technology developed within DOE to other government agencies and industry. ($1,470)	Continue vehicle propulsion technology assessments in industry and government; expand technology transfer activities, including conferences, workshops, publications, etc., to assure transfer of technology developed within DOE to other government agencies and industry. ($2,100)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY
Transportation
ELECTRIC AND HYBRID VEHICLE R&D
(dollars in thousands)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Electric Vehicle R&D	Continue development of advanced tubular-plate, lead-acid, sodium-sulfur and zinc-bromine battery systems technologies for integration with an existing experimental, single-shaft a.c. powertrain; fabricate and evaluate complete experimental proof-of-concept propulsion systems that incorporate these advanced battery and powertrain technologies. (By costing out prior years' obligations)	Complete development of advanced battery systems technologies for integration with an existing experimental, single-shaft a.c. powertrain; complete fabrication and evaluation of complete experimental proof-of-concept propulsion systems that incorporate these advanced battery and powertrain technologies. ($775)
	Explore the next generation of technologies for the single-shaft a.c. propulsion system that includes improved magnetic materials for the traction motors, reduction of electronics complexity and overall packaging improvement. (By costing out prior years' obligations)	Complete FY 1985 activities. ($C)
	Continue development of advanced dual-shaft a.c. propulsion system technology incorporating technologies for nickel-iron traction battery, a.c. induction motor, multi-speed automatic transaxle, and controller/power inverter, culminating with the development of complete experimental proof-of-concept propulsion systems tailored for and evaluated in test-bed vans. ($2,000)	Continue advanced dual-shaft a.c. propulsion system technology development program. ($2,000)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY
Transportation
ELECTRIC AND HYBRID VEHICLE R&D (cont.)
(dollars in thousands)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Electric Vehicle R&D (cont.)	Continue to develop lead-acid and nickel-iron battery technologies including electrolyte and thermal control systems. ($1,480)	Complete delivery of lead-acid and nickel-iron proof-of-concept complete vehicle battery systems, that are expected to meet vehicle performance goals of a range of 100 miles on a single charge, battery life of 60,000 vehicle miles, and acceleration and hill climbing capability better than a diesel vehicle; conduct R&D on the flow-through and immobilized electrolyte effort of lead-acid battery. ($1,400)
	Continue program to advance sodium-sulfur battery technology as required for electric vehicle application with emphasis on statistical analysis to determine optimum cell configurations. ($800)	Complete development of packaging, thermal management and optimum cell and module configuration analysis of sodium-sulfur battery for EV application. (By costing out prior years' obligations)
Hybrid Vehicle R&D	Develop advanced generation hybrid vehicle propulsion system technology by evaluating the most promising conceptual design, including alternative battery systems through computer simulation and analysis to provide industry with reliable data of the hybrid alternative. (By costing out prior years' obligations)	No activity. ($0)
Advanced Vehicle R&D	Conduct vehicle application studies of potential promising advanced systems and concepts, e.g., aluminum-air and lithium-metal-sulfide batteries, fuel cells, motors and controller technology to determine the feasibility of	No activity.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY
Transportation
ELECTRIC AND HYBRID VEHICLE R&D (cont.)
(dollars in thousands)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Advanced Vehicle R&D (cont.)	the technology for unlimited range electric or hybrid vehicle; conduct research on problems associated with nickel-cadmium batteries, including power density, weight reduction, cost reduction and maintenance. ($620)	($0)
Test and Evaluation	Continue collecting and refining data base to provide support to R&D activities and eliminate vehicle deficiencies; continue data collection and analysis as new technologies are integrated into vehicles for field evaluations; further reduce the number of active test sites and vehicles as contracts expire and vehicles are retired; prepare data and reports for use in workshops with site operators and industry. ($475)	Continue collection and analysis of data with emphasis on the viability of new techlogies integrated into operational fleet vehicles. ($350)
	Continue investigating and evaluating solutions to generic technical deficiencies in vehicles through the Site Operators' User Task Force: integrate a second round of improved components, e.g., transmissions, tubular lead-acid batteries, and advanced drivetrains, in selected fleet vehicles for field testing; prepare data and reports for application to symposia and workshops for the manufacturing, R&D and user industries; continue laboratory testing of develmental batteries to evaluate charge/discharge, temperature	Complete FY 1985 activities.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY
Transportation
ELECTRIC AND HYBRID VEHICLE R&D (cont.)
(dollars in thousands)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Test and Evaluation (cont.)	and life cycle characteristics. ($875)	($0)
	Continue laboratory and in-vehicle dynamometer testing and analysis of new battery and system technologies, e.g. zinc-chlorine battery system, a.c. propulsion system, d.c. controller and a new generation permanent magnet motor, developed both within and outside the Department over prescribed driving cycles to determine performance characteristics. ($1,529)	Continue laboratory and in-vehicle dynamometer testing and analysis of new battery and powertrain technologies including a.c. propulsion systems, integrated d.c. propulsion system with new generation p.m. motor, and improved nickel-iron and halogen battery system; conduct performance characterization testing of the prototype field test van developed jointly by DOE and EPRI. ($1,000)
	Continue life, durability and charging regime sensitivity testing of experimental batteries; use data from vehicles, post-mortem module analysis, and morphology tests to determine the most effective way of using the test batteries in a fleet application; prepare data and reports for application in workshops and for general distribution to the manufacturing and user community. ($500)	Identify charge/discharge sensitivity of immobilized electrolyte batteries to temperature variations and conduct limited post-mortem analysis and morphology tests. ($150)
	Continue to provide technical support to the electric vehicle site operators to assure that the technologies are adequately evaluated by the vehicle site operators who lack adequate technical staff and insure that the	Continue to provide technical support to electric vehicle site operators.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY
Transportation
ELECTRIC AND HYBRID VEHICLE R&D (cont.)
(dollars in thousands)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Test and Evaluation (cont.)	information obtained is disseminated to the supply industry. ($150)	($100)
	Integrate microprocessor battery charger/state-of-charge indicator systems into vehicles and field test at selected test sites; continue flame arrestor development. (By costing out prior years' obligations)	Conduct flame arrestor testing to determine its effectiveness in controlling flame propagation between battery cells. ($100)
	Complete construction of the d.c.-powered van initiated in FY 1984 and perform acceptance test. (By costing out prior years' obligations)	Project completed. ($0)
Technology Assessments and Transfer	Stimulate the transfer of technology developed within DOE to industry through workshops, seminars, technical manuals and assessments, conduct special test activities as appropriate to provide supportive data on new technologies determined to be promising candidates for industry products. (Funds are included as part of other key activities.)	Continue technology transfer activities including a Contractor Coordination Meeting for vehicle users, manufacturers, and the research community to discuss current progress and future coordinated R&D efforts; conduct workshops on battery development and testing and maintenance training for new technologies; hold seminars for the evaluation of advanced EV technologies and disseminate information in a timely fashion. ($200)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY
Transportation
TRANSPORTATION SYSTEMS UTILIZATION
(dollars in thousands)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Gas Mileage Guide	Publish and distribute the 1986 model year Gas Mileage Guide to 26,000 car and light truck dealers throughout the Nation to assist consumers in the purchase of fuel efficient vehicles. ($500)	Publish and distribute the 1987 model year Gas Mileage Guide. ($700)
Driver Awareness Training	Implement a nationwide fuel efficiency driver training program (DECAT) at selected regional sites and Nevada Operations Office to include driving instructors from State and local agencies, high schools and private industry. ($392)	No activity. ($0)
Ridesharing	Initiate a program to encourage ridesharing, including the identification and removal of barriers such as income tax and zoning regulations; assist State, local and private sector groups to develop initiatives to promote ridesharing. ($774)	No activity. ($0)
Technology Transfer	Collect, analyze and distribute transportation energy utilization data; analyze conservation impacts under various technological options and future fuel scenarios. (Activities funded from other program areas.)	Collect, assemble, and present transportation and energy data in the form of monthly data reports, an annual edition of the Transportation Energy Data Book and other energy impact information as required; assess market conditions for fuel efficient technologies; prepare baseline projections of future transportation energy use for Office program assessments. ($500)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY
Transportation
ALTERNATIVE FUELS UTILIZATION
(dollars in thousands)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Alcohols	Initiate introduction of methanol-powered passenger automobiles into the Federal fleet. Establish vehicle specifications, site locations, data collection and analysis systems and fuel stations. ($980)	No activity. ($0)
Synthetic Fuels	Continue basic fuel/engine performance/emissions investigations to identify and provide understanding of engine problems associated with the use of synthetic fuels; update data base with new information; initiate evaluation methodology for high-temperature engine environments. ($1,270)	Continue performance, emissions, wear, and optimization investigations on conventional and advanced engines using synthetic fuels; perform single and multi-cylinder dynamometer tests; update information data base and industry interface; provide industry and scientific community with standardized test fuels. ($1,400)
Methane (Gaseous Fuels)	Continue to conduct investigations on identified technology problems in diesel engines and update data base for industry use. ($200)	Continue investigation of technology and institutional barriers; conduct performance and emissions evaluations and update information data base. ($200)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY
Transportation
ADVANCED MATERIALS DEVELOPMENT
(dollars in thousands)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Ceramic and Ceramic Composites	Expand basic ceramic technology research projects to include development of improved powders, high-temperature properties evaluation of ceramic composites, ceramic/ceramic joining, nondestructive evaluation of green state ceramics, statistical concepts for design methodology, 3D modeling and processing, characterization and densification of green state ceramics; continue interface with government/industry research laboratories; continue utilization of advanced heat engines programs for test and evaluation sources. ($6,076)	Continue ceramic technology research projects in materials and processing, ceramic composites, thermal and wear coatings, joining, design methodology and monolithic structure life testing; expand projects to include scale-up of improved powder synthesis, composites, and life prediction for composite materials. ($9,290)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY
Transportation
CAPITAL EQUIPMENT
(dollars in thousands)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Advanced Materials Development	Procure unique laboratory equipment, e.g., ceramics injection molding unit, high-temperature cracks growth test instrumentation and ceramics hot isostatic press, to support the advanced materials development program, in such areas as the High Temperature Materials Laboratory when it is completed. ($1,960)	Complete FY 1985 capital equipment acquisition with unexpended balances. ($0)
Electric and Hybrid Vehicle R&D	Procure unique laboratory equipment, e.g., automated cycling and test instrumentation, for the Idaho National Engineering Laboratory to support the electric and hybrid vehicle test and evaluation program. ($980)	No activity. ($0)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY
Transportation
HIGH TEMPERATURE MATERIALS LABORATORY
(dollars in thousands)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
High Temperature Materials Laboratory	Finalize construction contract and complete site preparation, foundations, and major structural framing; initiate preparation of specifications for major items of research equipment. ($6,469)	Required funding to complete construction. ($2,700)
	Establish Industry Overview Committee; set up user centers operational procedures; manage acquisition of research equipment; design research staff requirements. (Funded from Advanced Materials Development Program)	Continue pre-operational support activities. ($310)

U.S. DEPARTMENT OF ENERGY
Office of Conservation
Transportation

Schedule 1-8-7

FISCAL YEAR 1986 BUDGET REQUEST
(Tabular Dollars in Thousands. Narrative Material in whole Dollars)

CONSTRUCTION PROJECT DATA SHEET

OAK RIDGE NATIONAL LABORATORY
FIELD OFFICE, LABORATORY OR ENERGY RESEARCH CENTER

39 EE TRANSPORTATION
PROGRAM

1. Title and Location of Project: High temperature materials laboratory, Oak Ridge National Laboratory, Tennessee
2. Project No.: 83-C-101/84-C-101
3. Date A-E Work Initiated: 4th Qtr. FY 1983
3a. Date Physical Construction Starts: 2nd Qtr. FY 1985
4. Date Construction Ends: 3rd Qtr. FY 1988
5. Previous Cost Estimate: $20,600,000
Date: April 1982 *
6. Current Cost Estimate: $19,300,000
Less Amount for PE & D:
Net Cost Estimate:
Date: August 1984

7. Financial Schedule:

Fiscal Year	Authorizations	Appropriations	Obligations	Costs
1983	$19,300	$ 1,000	$ 1,000	$ 0
1984	0	9,000	9,000	1,100
1985	0	6,600	6,600	4,200
1986	0	2,700	2,700	7,500
1987	0	0	0	5,500
1988	0	0	0	1,000

8. Brief Physical Description of Project:

The proposed project will consist of a new multi-story building to be approximately 64,500 sq ft. The building will house research laboratories, offices, and service areas, and the project will also include special equipment needed for high temperature materials research in the areas of mechanical behavior, physical property measurements, structural characterization, and materials syntheses and preparation.

U.S. DEPARTMENT OF ENERGY

Office of Conservation
Transportation
FISCAL YEAR 1986 BUDGET REQUEST
(Tabular Dollars in Thousands. Narrative Material in whole Dollars)

CONSTRUCTION PROJECT DATA SHEET

Schedule 1.B.7 (Cont'd)

OAK RIDGE NATIONAL LABORATORY
FIELD OFFICE, LABORATORY OR ENERGY RESEARCH CENTER

39 EE TRANSPORTATION
PROGRAM

1 Title and Location of Project	High temperature materials laboratory Oak Ridge National Laboratory, Tennessee	2 Project No.	83-C-101/84-C-101

8. Brief Physical Description of Project: (Cont'd)

Laboratories will be provided for the research groupings to be housed, space permitting, in the building (Mechanical Behavior, Physical Properties, Structural Characterization, and Materials Synthesis and Preparation). The building will include a mechanical behavior laboratory, several standard size laboratories, and smaller laboratories for individual research activities.

Office space will be provided to accommodate requirements for both single and multiple occupancy. Service and support areas will include a loading dock and a penthouse for the ventilation system. A combination freight and passenger elevator will be located near the dock entrance to facilitate deliveries to the upper floor and the equipment penthouse, and as an aid to handicapped persons.

Improvements to the land will include the limited relocation of existing utilities and provision for access, parking, and landscaping as required. Utilities will be extended from existing distribution systems. Planned long-term experiments, which may run continuously for a decade or longer, will be protected against power failure by emergency power from a diesel motor-generator. Drainage from the facility will flow to the existing plant collection and treatment systems.

9. Purpose, Justification of Need for, and Scope of Project:

The purpose of the HTML is to provide appropriate space and equipment to conduct long range and medium term research designed to provide an understanding and useful application of the relationships between a material's properties at elevated temperatures and its structure, composition, and environment. It is intended that the materials to be studied will be directly related to the high temperature material needs for advanced heat engines and other applications as identified in concert with industrial needs but which are of such high risk that the HTML provides unique facilities for study of these material problems. The HTML will also provide the concentration of expertise to provide solutions for complex elevated temperature materials problems in fossil and advanced energy systems.

U.S. DEPARTMENT OF ENERGY

Office of Conservation
Transportation

FISCAL YEAR 1986 BUDGET REQUEST
(Tabular Dollars in Thousands. Narrative Material in whole Dollars)

CONSTRUCTION PROJECT DATA SHEET

Schedule 1 B-7 (Cont'd)

OAK RIDGE NATIONAL LABORATORY
FIELD OFFICE, LABORATORY OR
ENERGY RESEARCH CENTER

39 EE TRANSPORTATION
PROGRAM

1. Title and Location of Project: High temperature materials laboratory
Oak Ridge National Laboratory, Tennessee

2. Project No.: 83-C-101/84-C-101

9. Purpose, Justification of Need for, and Scope of Project: (Cont'd)

A. Need for High Temperature Materials Research:

Materials limitations dominate virtually all advanced concepts for energy production and use. These limitations are most commonly associated with mechanical or chemical instability at elevated temperatures in more adverse environments. All advanced transportation propulsion systems require new materials to withstand the high operating temperatures necessary for increased cycle efficiencies. Lack of structural ceramic materials having the required reliability presently impedes the introduction of ceramic components into advanced heat engines such as vehicular gas turbines and high temperature diesels. Component failures due to erosion and corrosion processes are the chief causes of shut-downs in synthetic fuel pilot plants and in chemical processing plant components such as reformers and crackers. Corrosive attack of the cathodes in high temperature batteries based on the Na-S cell limits the performance of such batteries, which might otherwise be used for electric vehicle propulsion and in electric energy storage systems. An understanding of elevated-temperature-materials behavior would affect the United States energy program in the following areas:

1. Higher operating temperatures of energy-conversion systems such as heat engines governed by the Carnot cycle would increase the efficiency of the conversion of heat energy.

2. The reliability of structural components in service at elevated temperatures would be improved.

3. The high temperature materials problems that limit the feasibility of some advanced systems would be solved.

4. The conservation of fuel and scarce materials would be achieved.

5. Broad exploratory research holds the potential for the discovery of new properties of known materials and for the development of new classes of materials. New physical phenomena may be discovered that might allow entirely new energy systems to be invented. Such long-term research holds the possibility of contributing to the energy needs of the United States in a revolutionary way.

U.S. DEPARTMENT OF ENERGY

Office of Conservation
Transportation
FISCAL YEAR 1986 BUDGET REQUEST
(Tabular Dollars in Thousands. Narrative Material in whole Dollars)

CONSTRUCTION PROJECT DATA SHEET

Schedule 1 B 7 (Cont'd)

OAK RIDGE NATIONAL LABORATORY
FIELD OFFICE, LABORATORY OR
ENERGY RESEARCH CENTER

39 EE TRANSPORTATION
PROGRAM

1. Title and Location of Project:	High temperature materials laboratory Oak Ridge National Laboratory, Tennessee	2. Project No.	83-C-101/84-C-101

9. Purpose, Justification of Need for, and Scope of Project: (Cont'd)

B. Need for High Temperature Materials Laboratory:

Neither private industry nor another government agency is likely to fund the basic research needed to support advanced energy systems' materials needs. A comprehensive, Department of Energy (DOE)-supported laboratory is the most efficient medium- to long-range approach to the deficiencies that now exist. A DOE-dedicated laboratory, with its specialized equipment and personnel, would serve as an important national resource. Those factors favoring an HTML are listed below:

1. An HTML, with its staff of professionals from several disciplines, would be capable of addressing broad multi-faceted or multi-disciplinary questions concerning high temperature materials research.
2. An HTML would serve as a DOE resource, housing equipment and expertise in the specialized area of high temperature materials synthesis.
3. An HTML would improve the resolution and detection of high temperature materials phenomena through the development of uniform procedures for preparing, analyzing, and testing materials.
4. An HTML would serve as a DOE resource capable of performing difficult property measurements at high temperatures.
5. An HTML would be able to attack the problem of predicting long-term (10 to 30 years) service behavior from short-term tests by housing the needed long-term experiments.
6. An HTML would provide a center for broad exploratory research on matter at high temperatures (> 2,000°C), a regime that is relatively unexplored.

U.S. DEPARTMENT OF ENERGY

Office of Conservation
Transportation
FISCAL YEAR 1986 BUDGET REQUEST
(Tabular Dollars in Thousands. Narrative Material in whole Dollars)

Schedule 1 B 7 (Cont'd)

CONSTRUCTION PROJECT DATA SHEET

OAK RIDGE NATIONAL LABORATORY
FIELD OFFICE, LABORATORY OR
ENERGY RESEARCH CENTER

39 EE TRANSPORTATION
PROGRAM

1. Title and Location of Project: High temperature materials laboratory
Oak Ridge National Laboratory, Tennessee

2. Project No. 83-C-101/84-C-101

9. Purpose, Justification of Need for, and Scope of Project: (Cont'd)

7. An HTML, encompassing both fundamental and applied research, would expedite the transfer of fundamental information and results to technology and would provide an ideal environment for technology transfer for materials research results to the industrial sector.

C. Criteria for a High Temperature Materials Laboratory:

To meet the above specifications, an HTML must meet the following criteria:

1. It must have a strong basic materials-science program in the areas of high temperature materials, and it must have strong links with the academic community.

2. It must have companion programs such as the Ceramic Technology for Advanced Heat Engines Program, that extend from basic and applied research to engineering development related to the DOE missions.

3. It must work closely with industry to provide facilities and results that will further United States technology.

On the basis of applying these criteria to existing United States laboratories (industrial, nonprofit, and federal government) and university research centers, it was concluded that no facility now exists that has the required characteristics of the HTML.

D. The Oak Ridge Site:

ORNL is a suitable site for the establishment of an HTML because it has: (1) a strong materials-science program to form the nucleus of the basic research effort on high temperature materials, (2) many important projects in applied research and engineering for DOE-high-temperature-materials needs, (3) a long history of expertise in the area of high temperature materials technology, and (4) the extensive support facilities of a large multidisciplinary energy-mission laboratory.

U.S. DEPARTMENT OF ENERGY

Office of Conservation
Transportation
FISCAL YEAR 1986 BUDGET REQUEST
(Tabular Dollars in Thousands. Narrative Material in whole Dollars)

CONSTRUCTION PROJECT DATA SHEET

Schedule 1 B 7 (Cont'd)

OAK RIDGE NATIONAL LABORATORY
FIELD OFFICE, LABORATORY OR
ENERGY RESEARCH CENTER

39 EE TRANSPORTATION
PROGRAM

1 Title and Location of Project: High temperature materials laboratory
Oak Ridge National Laboratory, Tennessee

2 Project No. 83-C-101/84-C-101

9. Purpose, Justification of Need for, and Scope of Project: (Cont'd)

E. Research Programs for HTML:

The research on high temperature materials will be organized into six broad groupings. Areas of expertise encompassed by the staffs of the four groups that will be housed, space permitting, in the HTML itself are as follows:

1. Mechanical Behavior will include studies of creep, fatigue, fracture, and mechanical modeling.

2. Physical Properties will concentrate on thermal, electrical, optical, elastic, and magnetic properties, and thermometry.

3. Structural Characterization will contain facilities for high temperature x-ray and electron diffraction, electron and optical microscopy, and surface characterization methods (LEED, ESCA, etc.). The chief research areas will be phase stability and the kinetics of phase transformations.

4. Materials Synthesis and Preparation will provide specimens for the other groups in the HTML, will provide samples for external researchers, and will conduct research on synthesis techniques (i.e., high purity powders, single crystals, etc.).

Two other groups, Environmental Interactions and High Temperature Chemistry, representing additional areas of expertise required in broadly based high temperature materials research, will be housed in an adjacent building. Environmental Interactions will carry out investigations in the fields of oxidation, diffusion, erosion, mixed gas reactions, liquid metal corrosion, environmental effects on mechanical properties, etc. High Temperature Chemistry research will consider phase and defect equilibria and thermodynamic properties of high temperature materials. The high temperature chemistry of ceramics will be an area of special interest.

U.S. DEPARTMENT OF ENERGY
Office of Conservation
Transportation
FISCAL YEAR 1986 BUDGET REQUEST
(Tabular Dollars in Thousands. Narrative Material in whole Dollars)

Schedule 1-B-7 (Cont'd)

CONSTRUCTION PROJECT DATA SHEET

OAK RIDGE NATIONAL LABORATORY
FIELD OFFICE, LABORATORY OR
ENERGY RESEARCH CENTER

39 EE TRANSPORTATION
PROGRAM

1. Title and Location of Project: High temperature materials laboratory
Oak Ridge National Laboratory, Tennessee

2. Project No.: 83-C-101/84-C-101

9. Purpose, Justification of Need for, and Scope of Project: (Cont'd)

F. Estimates of Annual Costs of Operations:

The estimates of the annual costs of operations (FY 1984 dollars) for the research activities described in previous sections are based upon 68 people being physically housed in the facility. The estimated annual costs of materials, supplies, and services are $2,000,000. The estimated costs of the utilities are $970,000. The estimated annual costs of personnel including fringe benefits and overhead are $5,225,000.

It should be noted, however, that the initial staff of the HTML will be drawn from personnel already employed at ORNL. Thus, the incremental increase in annual costs of operation will be limited largely to the increased costs of utilities.

U.S. DEPARTMENT OF ENERGY

Office of Conservation
Transportation

FISCAL YEAR 1986 BUDGET REQUEST
(Tabular Dollars in Thousands. Narrative Material in whole Dollars)

CONSTRUCTION PROJECT DATA SHEET

Schedule 1-B-7 (Cont'd)

OAK RIDGE NATIONAL LABORATORY
FIELD OFFICE, LABORATORY OR
ENERGY RESEARCH CENTER

39 EE TRANSPORTATION
PROGRAM

1. Title and Location of Project: High temperature materials laboratory
Oak Ridge National Laboratory, Tennessee

2. Project No.: 83-C-101/84-C-101

10. Details of Cost Estimate:*

a. Engineering, design, and inspection at approximately 14% of construction costs, item b		$ 2,000
b. Construction costs		14,300
(1) Land improvements	$ 250	
(2) Building construction (approximately 64,500 sq ft at $124 per sq ft)	8,020	
(3) Other structures	380	
(4) Special facilities (laboratory hoods and exhaust system special temperature and humidity controls, and special equipment for research)	4,800	
(5) Utilities (electrical power, water, and communications)	850	
c. Office and laboratory furniture and standard research equipment		400
Subtotal		$16,700
d. Contingency at approximately 16% of above costs		2,600
Total Project Cost		$19,300

*This cost estimate is based on 90% design completion of the laboratory building and partial Title I design of the research equipment.

U.S. DEPARTMENT OF ENERGY

Office of Conservation
Transportation

FISCAL YEAR 1986 BUDGET REQUEST

(Tabular Dollars in Thousands. Narrative Material in whole Dollars)

CONSTRUCTION PROJECT DATA SHEET

Schedule 1 B-7 (Cont'd)

OAK RIDGE NATIONAL LABORATORY
FIELD OFFICE, LABORATORY OR
ENERGY RESEARCH CENTER

39 EE TRANSPORTATION
PROGRAM

1. Title and Location of Project: High temperature materials laboratory
Oak Ridge National Laboratory, Tennessee

2. Project No: 83-C-101/84-C-101

10a. Details of FY 1984 Obligations:

a. Engineering, design, and inspection	$ 1,000
b. Contingency at approximately 10% of above costs	100
Total FY 1984 Obligations	$ 1,100

11. Method of Performance:

Design and inspection will be on the basis of a negotiated architect-engineer contract. To the extent feasible, construction and procurement will be accomplished by fixed-price contracts and subcontracts awarded on the basis of competitive bidding.

U.S. DEPARTMENT OF ENERGY

Office of Conservation
Transportation

FISCAL YEAR 1986 BUDGET REQUEST

(Tabular Dollars in Thousands. Narrative Material in whole Dollars)

CONSTRUCTION PROJECT DATA SHEET

Schedule 1 & 7 (Cont'd)

OAK RIDGE NATIONAL LABORATORY
FIELD OFFICE, LABORATORY OR
ENERGY RESEARCH CENTER

39 EE TRANSPORTATION
PROGRAM

1. Title and Location of Project: High temperature materials laboratory
Oak Ridge National Laboratory, Tennessee

2. Project No.: 83-C-101/84-C-101

12. Funding Schedule of Project Funding and Other Related Funding Requirements:

	Prior Years	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	Total
a. Total Project Funding								
(1) Total facility costs								
(a) Construction line item	$ 0	$ 0	$ 1,100	$ 4,200	$ 7,500	$ 5,500	$ 1,000	$19,300
(b) PE&D	0	0	0	0	0	0	0	0
(c) Expense funded equipment . . .	0	0	0	0	0	0	0	0
(d) Inventories	0	0	0	0	0	0	0	0
Total Facility Costs	$ 0	$ 0	$ 1,100	$ 4,200	$ 7,500	$ 5,500	$ 1,000	$19,300
(2) Other project funding								
(a) R&D necessary to complete construction	$740	$ 60	$ 0	$ 0	$ 0	$ 0	$ 0	$ 800
(b) Other project-related costs	0	0	0	0	0	0	0	0
Total Other Project Funding	$740	$ 60	$ 0	$ 0	$ 0	$ 0	$ 0	$ 800
Total Project Funding [Item (1) and Item (2)] . . .	$740*	$ 60	$ 1,100	$ 4,200	$ 7,500	$ 5,500	$ 1,000	$20,100

*This total includes $740,000 for conceptual design prior to FY 1983.

U.S. DEPARTMENT OF ENERGY
Office of Conservation
Transportation
FISCAL YEAR 1986 BUDGET REQUEST
(Tabular Dollars in Thousands. Narrative Material in whole Dollars)
CONSTRUCTION PROJECT DATA SHEET

Schedule 1-B-7 (Cont'd)

OAK RIDGE NATIONAL LABORATORY
FIELD OFFICE, LABORATORY OR ENERGY RESEARCH CENTER

39 EE TRANSPORTATION
PROGRAM

1. Title and Location of Project: High temperature materials laboratory Oak Ridge National Laboratory, Tennessee

2. Project No: 83-C-101/84-C-101

12. Funding Schedule of Project Funding and Other Related Funding Requirements: (Cont'd)

b. Total Related Funding Requirement (Estimated Life: 50 Years)

(1) System operating costs	$ 2,970
(2) Programmatic operating expenses directly related to the facility	5,225
(3) Capital equipment not related to construction but related to the programmatic effort in the facility	400
(4) GPP or other construction related to the programmatic effort in the facility	0
(5) Other costs	0
Total Other Related Annual Funding Requirements	$ 8,595*

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements:

a. Total Project Funding

(1) Total facility costs

(a) Construction line item

No narrative required

(b) PE&D

No narrative required

*These costs are expressed in FY 1984 dollars.

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U.S. DEPARTMENT OF ENERGY

Office of Conservation
Transportation

FISCAL YEAR 1986 BUDGET REQUEST

(Tabular Dollars in Thousands. Narrative Material in whole Dollars)

CONSTRUCTION PROJECT DATA SHEET

Schedule 1 B 7 (Cont'd)

OAK RIDGE NATIONAL LABORATORY
FIELD OFFICE, LABORATORY OR
ENERGY RESEARCH CENTER

39 EE TRANSPORTATION
PROGRAM

1. Title and Location of Project:	High temperature materials laboratory Oak Ridge National Laboratory, Tennessee	2. Project No.	83-C-101/84-C-101

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements:* (Cont'd)

(c) Expense funded equipment

No narrative required

(d) Inventories

No narrative required

(2) Other project funding

(a) R&D necessary to complete construction

Approximately $740,000 was spent on conceptual design studies prior to FY 1984.

(b) Other project-related costs

No narrative required

b. Total Related Funding Requirement

The estimated useful life of the HTML is 50 years.

(1) Facility operating costs

These estimated costs are for utilities for the building and program activities, maintenance of the building and its systems, and janitorial services.

U.S. DEPARTMENT OF ENERGY

Office of Conservation
Transportation
FISCAL YEAR 1986 BUDGET REQUEST
(Tabular Dollars in Thousands. Narrative Material in whole Dollars)

Schedule 1 B-7 (Cont'd)

CONSTRUCTION PROJECT DATA SHEET

OAK RIDGE NATIONAL LABORATORY
FIELD OFFICE, LABORATORY OR
ENERGY RESEARCH CENTER

39 EE TRANSPORTATION
PROGRAM

1. Title and Location of Project: High temperature materials laboratory
Oak Ridge National Laboratory, Tennessee

2. Project No. 83-C-101/84-C-101

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements: (Cont'd)

(2) Programmatic operating expenses directly related to the facility

Programmatic operating expenses directly related to the activities described in Item 9 cover consumable materials and supplies' costs, personnel costs including fringe benefits, and miscellaneous costs.

(3) Capital equipment not related to construction but related to the programmatic effort in the facility

Capital equipment for programmatic activities is described in Item 9.

(4) GPP or other construction related to the programmatic effort in the facility

No narrative required

(5) Other costs

No narrative required

14. Incorporation of Fallout Shelters in Future Federal Buildings:

Efforts will be made, where feasible, to design for additional shelter space at little or no additional costs.

15. Incorporation of Measures for the Prevention, Control, and Abatement of Environmental Pollution at Federal Facilities:

The total cost of this project includes the costs of those measures necessary to assure compliance with Executive Order 12088. Sanitary waste will be discharged into existing sewers connected to adequate sewage treatment facilities. Airborne contaminants will be collected and filtered before the air is released to the atmosphere. Liquid and

U.S. DEPARTMENT OF ENERGY

Office of Conservation
Transportation

FISCAL YEAR 1986 BUDGET REQUEST
(Tabular Dollars in Thousands. Narrative Material in whole Dollars)

CONSTRUCTION PROJECT DATA SHEET

Schedule 1-B-7 (Cont'd)

OAK RIDGE NATIONAL LABORATORY
FIELD OFFICE, LABORATORY OR
ENERGY RESEARCH CENTER

39 EE TRANSPORTATION
PROGRAM

1. Title and Location of Project: High temperature materials laboratory
Oak Ridge National Laboratory, Tennessee

2. Project No.: 83-C-101/84-C-101

15. Incorporation of Measures for the Prevention, Control, and Abatement of Environmental Pollution at Federal Facilities: (Cont'd)

gaseous effluents and solid wastes resulting from operations within the new facility are not perceived to constitute a threat to the environment.

16. Evaluation of Flood Hazards:

This project will be located in an area not subject to flooding determined in accordance with Executive Order 11988.

17. Compliance with the National Environmental Policy Act and Floodplains/Wetlands Environmental Review Requirements, and Other Related Statutes:

In compliance with the National Environmental Policy Act, DOE Order 5440.1, the Council on Environmental Quality Regulations (40 CFR Parts 1500 - 1508), and the DOE NEPA Guidelines (45 FR 20694), an Environmental Assessment has been prepared for this project. The need for an Environmental Impact Statement has not yet been determined and is not anticipated.

Compliance with both the Clean Air Act and the Clean Water Act has been documented in the Environmental Assessment. As presently conceived, the operation of the completed project will not generate any air or water pollutants.

There are no known conflicts with the Floodplains/Wetlands Environmental Review Requirements. The proposed site for this project is neither in nor adjacent to wetlands or natural floodplains.

There are no known conflicts with either the National Historic Preservation Act or the Endangered Species Act.

18. Accessibility for the Handicapped:

This project will be accessible to the handicapped in accordance with the Architectural Barriers Act, P.L. 90-480, and implementing instructions in the Federal Property Management Regulations (41 CFR 1.1-91.6).

FY 1986 CONGRESSIONAL BUDGET REQUEST
PROGRAM OVERVIEW
STATE AND LOCAL ASSISTANCE PROGRAMS

The goal of the State and Local Assistance Programs is to encourage energy conservation initiatives on the State and local level through a mix of activities and programs, including direct financial assistance, personalized information services, technical assistance, and developmental demonstration projects to enhance State and private sector involvement in energy conservation. The Office of State and Local Assistance Programs administers the following programs in support of its goal:

- the Weatherization Assistance Program;
- the Schools and Hospitals Grants Program, also known as the Institutional Conservation Program;
- the Energy Policy and Conservation Act (EPCA) Grants, also known as the State Energy Conservation Program (SECP); and
- the Energy Extension Service (EES)

The first two programs were established to provide assistance to sectors of the economy experiencing particular difficulty in responding to the market signal of higher energy prices by making energy conservation investments. The EPCA Grants and the Energy Extension Service were established to provide funding to the States and territories for a variety of energy conservation activities, and to build a capacity within and among the States and territories to plan, develop, and carry out their own energy conservation and outreach programs.

The FY 1986 budget request for these programs represents the first year of a 5-year phaseout of federal funds -- a 20% per year decrease from 1985 levels, concluding in FY 1990. In FY 1985 and 1986, SLAP will work with States and private sector groups to transfer program operation experience and identify alternative funding sources for program activities.

The Weatherization Assistance Program increases the energy efficiency of residences occupied by low-income citizens across the country, particularly the homes of the elderly and the handicapped. It is estimated that approximately 12.6 million dwellings are occupied by low-income families. Through July, 1984, the Weatherization Assistance Program directly funded energy conservation efforts in over 1,300,000 homes. Funds allocated to the States in FY 1985 and 1986 will weatherize some 185,000 and 148,000 additional homes each year, respectively.

In addition to the direct provision of funding, the Weatherization Assistance Program Office undertakes a number of technical assistance and information activities to further encourage energy conservation in low-income homes.

models and the development of state specific energy use and consumption data bases are examples where SECP has aided the States and territories.

In FY 1986, SECP will provide technical and financial assistance to enable States to continue development and implementation of their best energy efficiency programs. SECP will also work with State Energy officials, local organizations and private interests to broaden the base of managing and funding program activities.

The Energy Extension Service provides tailored information, specialized training, and technical assistance to small scale energy users, such as small businesses, local governments, and homeowners, who in the aggregate consume 40% of the Nation's energy. States and territories have broad flexibility to develop those programs that will be most effective. EES serves an integrating and coordination function by bringing together existing resources and delivery mechanisms, providing them with new and updated information and sound technical advice.

In FY 1986, EES will continue its outreach and education activities to the energy consumer, and those organizations and leaders who influence the consumer. Emphasis on technology transfer will be increased. EES will work with States and private sector interests to multiply support for effective States programs and encourage private sector operation of profitable services.

In FY 1985, WAP will examine ways to refocus decreasing resources to maximize their impact and to complete ongoing tasks which will be of help to States and local agencies in future years. These include client education, development of quality control procedures, evaluation activities, innovative financing demonstrations, and business development opportunities for local agencies.

In FY 1986, efforts will focus on helping the States prepare for conducting weatherization activities independent of federal funds. "Lessons learned" will be provided to program managers, and 50 program opportunity grants will be provided to State and local agencies to demonstrate strategies for carrying out weatherization activities without federal funds.

The Schools and Hospitals Grants Program was established to encourage energy conservation in the institutional building sector. Public and private non-profit institutions use significant amounts of energy, the cost of which represents a large portion of their operating budgets. These institutions have difficulty financing capital improvements because of limited capital budgets, uncertain income, and limited borrowing capacities. The Schools and Hospitals Grants Program helps institutions overcome this difficulty by providing matching grants for energy audits and the installation of energy conservation measures. Through FY 1984, the program awarded 15,090 grants for energy conservation projects in over 38,000 school and hospital buildings. A 1982 Department of Energy evaluation found that grantees saved approximately 13% on energy consumption. Moreover, investments were cost-effective; total costs averaged $7.90 per barrel of oil equivalent saved. The average estimated payback was less than 2 years.

The Schools and Hospitals Grants Program Office has also undertaken projects to identify and develop alternative approaches to encouraging energy conservation in the institutional sector, including alternative financing methods to increase private sector funding, technical assistance for State and institutional staff, training in proper equipment operation and maintenance, and efforts to improve the quality of engineering studies procured by grantees. In FY 1985, a multi-year program strategy will be developed in conjunction with appropriate constituent groups to identify and implement methods to encourage energy conservation activity and investments, while phasing out the federal grant role.

In FY 1986, this strategy will be implemented. Beginning in FY 1986, a portion of the appropriation will be used for developmental grants to States to assist institutions in gaining access to alternative funding for energy conservation projects. Funding requested for FY 1986 will provide approximately 980 grants to institutions, covering approximately 2400 buildings.

Through the EPCA Grants (the SECP Program), the States have developed and implemented a wide range of programs, including but not limited to the establishment of thermal and lighting efficiency standards, energy efficient procurement practices, ride sharing programs, technical assistance to business and industry, and the development of an emergency planning and response capability. The States have integrated energy planning and energy conservation into private and public sector economic development. Community energy management concepts, the use of energy factors in economic development

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
ENERGY CONSERVATION
STATE AND LOCAL ASSISTANCE PROGRAMS

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1984 Appropriation	FY 1985 Appropriation	FY 1986 Base	FY 1986 Request
State and Local				
Weatherization....	$290,000	$191,113	$191,113	$152,890*
Schools and Hospitals.......	$ 48,000	$ 47,043	$ 47,043	$ 37,634*
EPCA Grants.......	$ 24,000	$ 23,522	$ 23,522	$ 18,818
Energy Extension Service.........	$ 10,000	$ 9,801	$ 9,801	$ 7,841
Program Evaluation	0	$ 1,960	$ 1,960	$ 0
Program Direction.	$ 8,166	$ 9,710**	$ 9,710	$ 8,396
Total SLAP..............	$280,166	$283,149	$283,149	$225,579
Funding from monies recovered from violations under Emergency Petroleum Allocation Act..				$190,524
Staffing Total FTEs	181	180	180	149

Authorizations: National Energy Extension Service Act, Title V, P.L. 95-39;
Energy Policy and Conservation Grant Program (Energy Policy and Conservation Act, P.L. 94-163);
Energy Conservation and Production Grant Program (Energy Conservation and Production Act, P.L. 95-385);
Schools and Hospitals Grant Program (National Energy Conservation Policy Act, Section 301-304, P.L. 95-619);
Other Local Government Buildings Grant Program (National Conservation Policy Act, Sec. 310-312, P.L. 95-619);
Weatherization Assistance Program (Energy Conservation and Production Act, Sec. 411, P.L. 945-385);
Department of Energy Organization Act, P.L. 95-91;
P.L. 93-577, The Federal Non-nuclear Energy Research and Development Act of 1974

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*The requested FY 1986 funding levels are contingent upon enactment of legislation to utilize monies recovered by the U.S. Government from petroleum pricing and allocation violations under the Emergency Petroleum Allocation Act of 1973, as amended. If receipts from this source are insufficient to match the appropriation, the balance will be derived from the general fund.

**Reflects savings of $251,000 for Section 2901 of the Deficit Reduction Act of 1984 (P.L. 98-369).

SUMMARY OF CHANGES
DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
STATE AND LOCAL ASSISTANCE PROGRAMS
(In thousands of dollars)

FY 1985 Appropriation enacted less 2901 recision	$283,149
Program increase and decreases:	
Weatherization	
o Reduction in grant funding	- 38,223
Schools and Hospitals	
o Reduction in grant funding	- 9,409
EPCA Grants	
o Reduction in grant funding	- 4,704
Energy Extension Service	
o Reduction in grant funding	- 1,960
Program Evaluation	
o Orderly completion of ongoing evaluation activities	- 1,960
Program Direction	
o Reduction in funds available for contract support	- 715
o 5% pay reduction	- 348
o 2901 recision for overhead	- 251
Subtotal	- 1,314
	225,579
Less funds from monies recovered from violations under the Emergency Petroleum Allocation Act	- 190,524
FY 1986 budget request	$ 35,055

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
STATE & LOCAL ASSISTANCE PROGRAMS

NARRATIVE JUSTIFICATION

The goal of the State and Local Assistance Program is to encourage energy conservation initiatives on the State and local level through a mix of activities and programs, including direct financial assistance, technical assistance, and developmental/demonstration projects to enhance State/private sector involvement in energy conservation. The funds requested for the Weatherization Assistance Program and the Schools and Hospitals Grants Program are contingent upon enactment of legislation to utilize monies recovered by the U.S. Government from petroleum pricing and allocation violations under the Emergency Petroleum Allocation Act of 1973, as amended, in instances where the overcharged customers cannot be identified and repaid.

The Office of State & Local Assistance Programs administers the following programs in support of its goal.

Weatherization	FY 1984	FY 1985	FY 1986 Congressional Request
	$190,000,000	$191,113,000	$152,890,000*

The FY 1986 Congressional Request for Weatherization is $152.9 million.

The Weatherization Assistance Program increases the energy efficiency of residences occupied by low-income citizens across the country, particularly the homes of the elderly and the handicapped. This contributes to our national goal of reducing dependence on foreign oil by permanently decreasing the energy consumption in those homes.

This budget request represents the first year of a 5-year phase-out of program activity (20 percent per year decrease from the 1985 level of $190 million), concluding in FY 1990. A 1984 Department of Energy study shows that Weatherization saves, on the average, 13-14% of the home heating energy costs. Energy savings averaged 2.5 barrels of oil equivalent per household per year (a payback period of over 13 years, and $13.4 million in avoided energy costs annually at $29 per barrel of oil.) The study also shows that in 23% of the sample group, energy consumption went up during the year after weatherization. DOE has commissioned a further analysis of factors contributing to this behavioral changes.

It is estimated that 12.6 million dwellings, at 125 percent of the OMB poverty level, are occupied by low-income families. As a result of recent amendments to the program requlations, States, beginning in 1985, may choose to use the LIHEAP eligibility criterion which may increase the universe of eligible homes to approximately 22 million. At the same time the States will be able to spend more on each home assisted by averaging their expenditures, thereby weatherizing fewer homes. As of September, 1984, more than 1,300,000 were weatherizied under this program.

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*The requested FY 1986 funding levels are contingent upon enactment of legislation to utilize monies recovered by the U.S. Government from petroleum pricing and allocation violations under the Emergency Petroleum Allocation Act of 1973, as amended. If receipts from this source are insufficient to match the appropriation, the balance will be derived from the general fund.

In FY 1985, we will look at ways to refocus diminishing resources to maximize their impact and to complete a number of tasks which will be of use to the States and local agencies in the outyears. These activities include client education, determining the best approaches to weatherizing mobile homes, developing enhanced quality control procedures, and follow-on evaluation activities to the energy savings study completed in FY 1984. In addition, work will continue in the area of innovative financing of low-income multi-family residences and business development opportunities for local action agencies.

In FY 1986, the program will redirect its efforts toward maximizing the impact of reduced Federal funding and helping States and local agencies prepare for conducting weatherization activities independent of federal funds.

While we are reducing the funding levels and redirecting program efforts, we will continue to take steps necessary to ensure effective management of program activities. This includes grant awards and grant administration functions, tracking of cost and production data, and monitoring of grantee performance. We will also reevaluate business management requirements in light of the program phase-out and changes in program direction.

In FY 1986, we will initiate the development of a series of "lessons learned" which can be used by program grantees at State and local levels as the DOE program is phased out. This initiative will focus on our experience as it relates to the weatherization approaches and strategies and business management practices which have proven most effective over the past nine years.

In FY 1986, we will issue 50 program opportunity grants for States and local agencies to apply for funds to demonstrate strategies for carrying out weatherization activities without Federal funds. These grants will fall into two categories: business development activities, the profits of which will be used to carry out low-income weatherization, and alternative financing strategies for weatherizing low-income dwelling units, especially multi-family residences.

Within the constraints of the 1984 legislative changes in the program regulation, DOE will encourage the States to look closely at assisting more homes by spending less on each home.

In FY 1986, funds allocated to the States will provide for the weatherization of 148,000 low-income residences.

Schools & Hospitals	FY 1984	FY 1985	FY 1986 Congressional Request
	$48,000,000	$47,043,000	$37,634,000*

The FY 1986 Congressional Request for the Schools and Hospitals Grant Program is $37.6 million. The Schools and Hospitals Grant Program was established to encourage energy conservation initiatives in the institutional building sector. Such public and private non-profit institutions use significant amounts of energy, the cost of which represents a large proportion of their operating budgets. In addition, many such institutions have difficulty financing capital improvements because they have limited capital budgets, uncertain income, and limited borrowing capacities.

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*The requested FY 1986 funding levels are contingent upon enactment of legislation to utilize monies recovered by the U.S. Government from petroleum pricing and allocation violations under the Emergency Petroleum Allocation Act of 1973, as amended. If receipts from this source are insufficient to match the appropriation, the balance will be derived from the general fund.

This budget request represents the first year of 5-year phase-out of program activity (20 percent per year decrease from the FY 1985 level of $48 million concluding in FY 1990). A 1982 DOE evaluation found that grantees saved approximately 13% on energy consumption. More over, investments were cost-effective; total costs averaged $7.90 per barrel of oil equivalent saved. The average estimated payback was less than 2 years.

A major mechanism for supporting energy conservation in the target sector has been the use of matching grants for energy audits and the installation of energy conservation measures. Through FY 1984, the program awarded 15,090 grants for energy conservation projects in over 38,000 school and hospital buildings. The program has also had notable secondary effects through stimulation of energy-saving activities and developing expertise in energy conservation in participating institutions.

An important energy conservation role of the program is to take the initiative in identifying and developing alternative approaches to promoting energy conservation in the institutional building sector. In FY 1985, the program will:

- demonstrate various alternative energy conservation financing methods to increase private sector involvement in funding efficiency improvements in the target sector;
- conduct a pilot project, in cooperation with State governments, to combine unfunded schools and hospitals grant applications to create more attractive candidates for third party energy conservation financing;
- determine the best conservation actions taken by grantees and share this information with others;
- improve the quality of technical assistance services procured by grantees; and
- insure better institutional staff awareness of proper equipment operation and maintenance (O&M) procedures.

Also in FY 1985, efforts will be made to work with appropriate constituent organizations to build a multi-year program strategy consensus. The goal of the 5-year strategy is to define and implement systems and methods for encouraging institutional energy conservation activity and investments, while phasing-out the Federal grant role.

In FY 1986, the program will implement this strategy while continuing to develop and share insights and information gained from the efforts mentioned above. Beginning in FY 1986, ICP will use a portion of the appropriation for developmental grants, the purpose of which would be to sponsor activities by States to assist their non-profit institutions to gain access to alternative sources of financing energy conservation. Case studies resulting from these activities will be used to assist other States in preparing for the termination of Federal grants for institutional energy conservation.

The $37.6 million requested for FY 1986 will fund approximately 980 grants, covering 2400 buildings.

EPCA Grants	FY 1984	FY 1985	FY 1986 Congressional Request
	$24,000,000	$23,522,000	$18,818,000

The FY 1986 Congressional Request for the EPCA Grants, also known as the State Energy Conservation Programs (SECP), is $18.8 million.

SECP provides States with the means to plan, establish and implement energy conservation programs, that reduce energy consumption in the State. SECP programs require a State match of funds or services.

The SECP supported the States in the development of conservation and renewable resources activities that addressed the specific energy issues of each State. The States have developed and are maintaining:

(a) an energy emergency planning and response network

(b) a database of information on energy use and energy conservation efforts statewide

(c) a mechanism for implementing national energy policy at both the state and local levels

(d) a state-wide "network" of organizations involved in energy activities.

The state offices are devoting increasing efforts to assisting local governments in the development of local energy management capability. For example, States utilized SECP resources to plan how the Warner Amendment funds would be allocated among all priority needs.

SECP provides States the support for necessary analysis, planning and implementation of energy efficiency programs. In FY 85, increased emphasis is being placed on program evaluation to determine the most effective energy programs. The identification of good evaluation models, and the development of innovative evaluation methods are being used by the States to improve energy programs.

Most States have already taken steps to integrate and factor energy into the ongoing economic life of the State and communities within the State. A funding level of $18.8 million for SECP in FY 1986 will enable the program to encourage States to continue the development and implementation of their best energy efficiency programs. It is anticipated that these activities will be phased out at a rate of 20% per year, with program termination in FY 1990. In 1986, efforts will be initiated to work with states to broaden the base of managing and funding conservation programs in anticipation of reduced federal funding. Grant awards will be made at times most appropriate to individual State funding cycles and DOE Support Office workload. The bulk of the grants will be awarded in May-June, 1986.

Energy Extension Service	FY 1984	FY 1985	FY 1986 Congressional Request
	$10,000,000	$9,801,000	$7,841,000

The FY 1986 Congressional Request for the Energy Extension Service (EES) is $7.8 million. EES provides tailored information, specialized and technical assistance to small scale energy users (i.e. small businesses, local governments and homeowners) to help them decide what are their most effective and productive energy conservation and renewable options. Fifty states and seven territories receive funding and have broad flexibility to develop effective programs. Like SECP, EES requires a state match of funds or services. The program utilizes existing organizations and programs, so that EES activities supplement or complement other established programs and services.

The demonstration of commercially available technologies/techniques, hands-on workshops, on-site technical assistance and "how-to" workbooks are principal methods utilized to meet the needs of the energy consumer. EES functions as an integrating and coordinating mechanism for existing resources and delivery mechanisms, providing them with new/updated information and backing them with sound technical advice. EES also provides a referral service to assist energy consumers. It serves as a laboratory for demonstrations and evaluations of different delivery services for technology transfer to all interested parties.

EES has demonstrated that it is a tested and proven mechanism for accomplishing technology transfer through:

(a) connecting energy users, through personalized and tailored information services, the most effective and appropriate energy efficient measures to meet their needs; and, as a direct result,

(b) increasing the market for energy equipment, materials, and services offered by the private sector, as well as applications for new technologies arising from research and development.

A funding level of $8 million in FY 1986 will enable EES to deliver energy efficient technology to consumers by:

(a) continuing to identify effective delivery mechanisms;

(b) analyzing and evaluating existing techniques;

(c) recommending and implementing proven methodologies; and,

(d) educating not only the energy consumer but those organizations and leaders who influence energy consumers.

Two major thrusts in FY 1986 will be to:

(1) develop with State and local governments a new form of program that spells out roles and relationships and increases the use of State resources for State needs, and

(2) develop with States and private interests support for effective State programs, and encourage private operations of profitable services.

It is anticipated that these activities will be phased out at a rate of 20% per year with program termination in FY 1990.

EES grant award dates will vary from State to State during FY 1986. Grant awards will be made at times most appropriate to individual State funding cycles and DOE Support Office workload. The bulk of the grants will be awarded in May-June, 1986.

Program Direction	FY 1984	FY 1985	FY 1986 Congressional Request
	$8,116,000	$9,710,000	$8,396,000

The FY 1986 Congressional Request for Program Direction is $8,396,000.

The staffing level for program direction in FY 1986 is 149 FTE down from 180 FTE in FY 1985. This FTE request will support 39 FTE in headquarters and 110 FTE in six field offices. Emphasis is being placed on monitoring of the grant activities to identify areas which provide opportunities to offer technical assistance and to reduce the potential for waste, fraud and abuse.

Also, the FY 1986 request takes into account a $348,000 reduction as a result of the proposed 5% pay cut for Federal employees and in FY 1985, the 2901 rescission.

Program Direction funds will also be used for contractor support as required to provide support for the analysis, evaluation and technical assistance activities of the office. These activities include evaluation of energy conservation measures as they apply to the grant programs, transfer of technologies, techniques or applications of technology between and among the States to improve the operation and efficiency of the grant programs, and technical assistance to grantees.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
STATE AND LOCAL ASSISTANCE PROGRAMS
KEY ACTIVITY SUMMARY
($ in 000's)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Weatherization Assistance Program	Refocus resources to maximize impact. Activities will include client eduction, improvement of quality control procedures, determining best approaches to weatherizing mobile homes, and follow-on evaluation work. Continue efforts to develop innovative financing approaches and business development opportunities for local action agencies. Weatherize 185,000 dwelling units. ($191,113)	Maximize impact of reduced federal funding, in anticipation of 5-year phaseout of federal funds. Develop series of "lessons learned" to transfer successful program operation strategies to program grantees. Issue 50 program opportunity grants to State and local agencies to demonstrate strategies for carrying out weatherization activities without federal funds. Weatherize 148,000 dwelling units. ($152,890)
Schools and Hospitals Programs	Work with constituent organizations to build multi-year program strategy consensus to encourage energy conservation activity and investment while phasing out federal funds. Implement projects demonstrating alternative financing approaches. Implement pilot project to combine unfunded grant applications to attract third party financing. Initiate efforts to improve the quality of technical assistance services procured by grantees. Train institutional managers in proper operations and maintenance techniques.	Implement strategy developed in FY 1985. Use a portion of appropriation for developmental grants to states to assist non-profit institutions to gain access to alternative financing sources for energy conservation projects. Prepare case studies based on these activities to assist States in preparing for termination of federal grants. ($37,634)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
STATE AND LOCAL ASSISTANCE PROGRAMS
KEY ACTIVITY SUMMARY
($ in 000's)

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Schools and Hospitals Program (cont.)	Provide approximately 1200 grants to institutions. ($47,043)	
EPCA Grants (State Energy Conservations Programs)	Provide matching grants to States to maintain energy emergency planning response capability, an infrastructure for implementing national energy policies and initiatives, and statewide network of organizations involved in energy activities. Increased emphasis on continued, improved program evaluation and information exchange with States. ($23,522)	Provide matching funding to continue activities implemented in FY 1985. Work with States to further develop and maintain energy emergency planning capability. Work with States and private groups to broaden the base of managing and funding conservation programs in anticipation of reduced federal funding. ($18,818)
Energy Extension Service	Provide matching grants to States to continue offering specialized technical assistance to small-scale energy users. ($9,801)	Provide matching funding to continue activities implemented in FY 1985. Transfer appropriate new technologies to individuals and private sector groups thereby increasing market for private sector energy services. In anticipation of reduced federal funding, work with States and private sector groups to: 1) craft a new form of program that increases the use of State resources and 2) multiply support for State activities and encourage private sector operation of profitable activities. ($7,841)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
STATE AND LOCAL ASSISTANCE PROGRAMS
KEY ACTIVITY SUMMARY
($ in 000's)

Key Activity	Estimated Activities During FY 1985	Planned Activties During FY 1986
Program Evaluation	Evaluate energy savings and other impacts of SLAP grant programs. ($1,960)	Close out activities begun in FY 1985. FY 1986 evaluation activities will be undertaken in the normal course of program direction. ($0)

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
ENERGY CONSERVATION
MULTI-SECTOR

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1984 Appropriation	FY 1985 Appropriation	FY 1986 Base	FY 1986 Request
Multi-Sector (CE)				
National Appropriate Technology and Assistance Service				
Operating Expenses........	500	1,470	1,470	1,000
Capital Equipment.........	0	0	0	0
Subtotal................	500	1,470	1,470	1,000
Energy Related Inventions Program				
Operating Expenses..........	3,000	4,900	4,900	5,000
Capital Equipment...........	0	0	0	0
Subtotal..................	3,000	4,900	4,900	5,000
Energy Conversion and Utilization Technologies				
Operating Expenses..........	8,945	15,608	15,608	19,190
Capital Equipment...........	0	1,666	1,666	1,000
Subtotal..................	8,945	17,274	17,274	20,190 **
Program Direction (ECUT)				
Operating Expenses..........	277	284 *	284	510
Subtotal..................	277	284	284	510
Total				
Operating Expenses........	12,722	22,270	22,270	25,750
Capital Equipment.........	0	1,666	1,666	1,000
Multi-Sector.............	12,722	23,928	23,928	26,700
Staffing				
Total FTE's	5	6	6	9

Authorization: P.L. 93-577, Federal Nonnuclear Research and Development Act of 1974.
P.L. 95-91, Department of Energy Organization Act.

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* Reflects savings of $8,000 for Section 2901 of the Deficit Reduction Act of 1984 (P.L. 98-369).

** FY 1986 amount does not reflect a reduction of $700,000 for prior year deobligation Management Initiative Savings

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
ENERGY CONSERVATION
MULTI-SECTOR

(In thousands of dollars.)

FY 1985 Conference mark less 2901 rescission	$23,928
National Appropriate Technology Assistance Service	
Decrease activity	-470
Inventions Program:	
Increase level of support for inventors	+100
Energy Conversion and Utilization Technologies	
Combustion and Thermal Sciences:	
Increase research on convective/radiative heat transfer, pulsed combustion, microemulsion fuels, direct conversion technology, and advanced energy conversion devices	+970
Materials:	
Increase research on materials by design, new ceramics processing techniques, high-performance insulation, ceramics corrosion, and ceramics	+1,168
Catalysis/Biocatalysis:	
Increase research on direct use of enzymes in biochemical reaction processes and catalysis by	+1,285
Tribology:	
Increase research on high-temperature lubricants, tribological coatings, and friction and wear testing; eliminate data retrieval system, and analyses of tribological sinks	+585
Innovation:	
Eliminate activity	-576
International Research Monitoring:	
Initiate activity to monitor foreign research applicable to Conservation	+150
Plant and Capital Equipment:	
Reduce rate of acquisition of analytical instrumentation for combustion and biocatalysis research	-666
Program Direction:	
5% pay reduction	-25
2901 rescission	-8
price out of staffing	+259
FY 1986 budget request	26,700

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL BUDGET REQUEST
PROGRAM OVERVIEW
Energy Conservation - Multi-Sector

This request is to provide $20,700,000 for the Energy Conversion and Utilization Technologies (ECUT) program, $5,000,000 for the Energy-Related Inventions Program and $1,000,000 for the National Appropriate Technology Assistance Service program for a total request of $26,700,000 for Multi-Sector.

Energy Conversion and Utilization Technologies ($20,700,000)

The primary mission of the Energy Conversion and Utilization Technologies (ECUT) Program is to expand and solidify the generic technology base that supports initiatives by both the DOE end-use Conservation programs and U.S. private industry to improve the efficiency of energy conversion and utilization systems. ECUT also assesses the future international competitiveness of U.S.-based energy conversion and end-use technology by monitoring the status of energy conservation related research in foreign countries. ECUT research is aimed at understanding and improving techniques, processes, and materials that push the thermodynamic efficiency of energy conversion and usage beyond the state-of-the-art.

There are four distinguishing features of ECUT research compared to other research programs: (1) it is a program of directed basic research (problem oriented) that anticipates future end-use sector needs, (2) it focuses on solving problems that may be common to more than one energy-consuming sector (for example, understanding combustion phenomena), (3) it makes a concerted effort to seek out, encourage, and support new ideas and concepts, and (4) it provides predictive models and design tools useful to the private sector in achieving greater energy productivity. ECUT has a highly decentralized management structure already in place that stands ready to effectively expand the program over the FY 1985 funding levels.

ECUT currently conducts programs in four interdisciplinary research areas: Combustion and Thermal Sciences, Materials, Biocatalysis, and Tribology. Each of these activities contributes to accomplishing the following goals:

- Establish the feasibility of revolutionary concepts that offer the potential for significantly reducing energy consumption in conversion processes and energy end-use.
- Monitor advances in basic scientific research both in the U.S. and abroad and evaluate them for applicability to energy conservation.
- Carry out exploratory development on novel or innovative conservation concepts.
- Expand and place on firm footing the technology base for energy conservation technologies.
- Ensure a continual flow of information on new conservation-related technical advances to the DOE end-use sector Conservation programs and to private industry.

Major FY 1984 accomplishments by ECUT include the following:

Combustion and Thermal Sciences

- Successfully identified preflame reactions evident in the chemical processes leading to the occurrence of knock in spark ignition engines. Completed initial experimental and chemical kinetic modeling studies for n-butane, isobutane and propane as the first steps in determining the nature of the chemical processes leading to sudden increases in heat release rates, which are believed to cause engine knock.

- Completed initial experiments that suggested that alternative fuels for use in diesel engines with swirl may be expected to have similar performance independent of their respective cetane ratings. Several different fuel samples provided by the Transportation program in Conservation were studied with a focus on autoignition and combustion. Samples included a petroleum based fuel, a broad-cut petroleum fuel and a coal-derived fuel.

- Completed initial computer modeling and supporting experiments to study single- and multi-component fuel sprays. Results will be analyzed to assess fuel spray properties relative to formation of soot and particulates and to study the corrosion/erosion of combustion equipment as a result of fuel combustion.

- Determined that the source of re-ignition in a pulse combustor is actually a continuous combustion process which occurs in the combustion chamber and that short-lived rapid combustion is responsible for the pressure rise which causes the pulsations. These findings are important to clarifying the controlling basic principles by which pulse combustion devices operate.

- Completed first experiments using ECUT Reversing Flow Facility to develop performance profiles of annular regenerators. Efforts conducted in cooperation with the Office of Buildings and Community Systems and the Office of Transportation Systems.

Materials

- Successfully transferred to private industry the $(Fe, Ni)_3V$ long range ordered (LRO) base alloy. One company has successfully prepared 50-100 pounds of this LRO alloy and rolled it to 0.03 inch thick sheets using standard commercial processes commonly used for superalloys. Another corporation is testing specimens provided by ORNL for use as high speed brake material for aircraft. A third company has investigated various LRO alloys via powder metallurgy techniques for a variety of (undisclosed) high temperature applications.

- Sponsored an international symposium on ductile ordered intermetallic alloys at the annual meeting of the Materials Research Society in Boston.

- Demonstrated castability and weldability of several compositions of the ductile ordered intermetallic alloy, nickel aluminide (Ni_3Al). The breakthrough by Oak Ridge National Laboratory researchers in making this intermetallic alloy highly ductile by the addition of trace Boron was given the prestigious IR-100 award by Industrial Research Magazine.

- Demonstrated the feasibility of joining ceramics to other ceramics or metals by using electromagnetic energy to heat the junction region. Reliable techniques for joining ceramics together is one of the major problems needing to be resolved to make structural ceramic components feasible for use in heat engines and other high temperature applications.

- Successfully determined the effects which the experimentally available range of directed-energy beam (ion implanter, laser) parameters (species, energy, fluence) have on the properties measured in conventional mechanical properties tests on a variety of surface modified ceramic materials (SiC, Si_3N_4, Al_2O_3, TiB_2).

Catalysis/Biocatalysis

- Issued RFP soliciting novel bioreactor concepts which may make it economic to produce chemicals biocatalytically; initiated contract research on several concepts.

- Successfully applied previously ECUT developed kinetic models to genetic instability effects in different bioreactor configurations. (It is important for a bioprocess engineer to know how a microorganism behaves and how fast it reproduces in order to scale up a fermenter.

- Developed a simple theoretical force-field model of enzymes which can predict how enzymatic (biocatalytic) activity varies as a function of enzyme structure. This permits the prediction of how to "tie down" (immobilise) an enzyme in a bioreactor and still retain its catalytic activity.

- Demonstrated that bacteria with chromosomally integrated plasmid copies grow normally. This is important because the plasmid carries the desired information to make the microorganism produce a desired product; inserting it into the chromosome stabilizes the information so it is not lost upon cell division. All of this effort would have been for naught if the altered microorganism did not grow normally.

- Demonstrated feasibility of maintaining biocatalytic activity at higher product concentration in non-aqueous environments. This is important because the economics and energy saving potential of biocatalyzed chemical production processes are very strongly dependent upon achieving increased concentration of the desired reaction products in the fermentation "broth."

Tribology

- Developed a modified four-ball test sequence that obtained excellent correlations between the friction coefficients and other properties of 12 engine oils and the fuel economy increases resulting from use of the oils in the engines of a fleet of automobiles tested by the American Society for Testing and Materials (ASTM). This inexpensive laboratory test, which has now been approved by ASTM as a valid screening test, can reduce the cost of running a full-scale fleet test.

- Tested model lubricating compounds in frictional and oxidation stability experiments. Additive-base oil and additive-additive interaction studies confirmed that the polar species in base oils control the additive performance level by chemically reacting with the additives. Knowing this fact will make it possible to attempt to synthesize this "slipperiest" fraction of the oil. These polar molecules exhibit a coefficient of friction of 0.041, which is lower than any lubricant on the market today.

- Elucidated and published a new theory on the mechanism of "hot spots" in ceramics under extreme pressure and temperature. This publication also explained the triboluminescence that was first seen several years ago. The paper is an important guide to future research needs for the tribology of ceramics.

- Verified the chemical dissolution theory of tool wear and determined the amount of hard coatings necessary for particular applications. This research will enable industry to systematically implant tribological coatings for cams, gears, tool bits, etc., in order to enhance low friction and wear properties on less expensive substrates.

- Published results of detailed studies of tribological sinks (energy losses) in nine sectors of the U.S. economy. This report and a subsequent paper, which were presented at several technical meetings, quantified major tribological losses and derived more definitive data than the ASME reports of several years ago. This research provided the underpinning for a definitive long-range program plan for the ECUT Tribology program.

Energy-Related Inventions Program ($5,000,000)

The Energy-Related Inventions Program (ERIP), initiated under the Federal Non-Nuclear Research and Development Act of 1974, provides first for evaluation of inventions by the Office of Energy-Related Inventions (OERI) in the National Bureau of Standards (NBS), the Department of Commerce (DOC); and then, assistance by the DOE Energy-Related Inventions Program for inventions identified by OERI as promising. The program gives particular attention to small businessmen and individual inventors by assisting the NBS-recommended inventors in developing and/or commercializing their inventions.

Through FY 1984, NBS had evaluated 20,600 applications and recommended 272 to DOE for further consideration. DOE has provided support to 192 inventors, including $14 million in grants for the purpose of developing their inventions. Of those receiving financial assistance, 36 inventions have entered the market, have cumulative sales totaling $110 million, and by thesehave created 976 new jobs. In 1984, the products and processess represented by these inventions will have saved, according to the inventors' estimates, around $20 million in energy.

The following summarizes three successful DOE-funded projects:

o One of the more successful projects is the commercial development of a process of manufacturing aluminum fuel cylinders reinforced with glass filaments for use as automobile fuel tanks. Natural gas is compressed to high pressures and carried in the tank as fuel for ordinary internal combustion engines, e.g., cars and trucks. Aluminum Corporation of America (ALCOA) subsequently purchased the development and presently markets the cylinders. According to ALCOA, natural gas has a 50¢ price advantage over a gallon of gasoline, and its use also results in reduced engine maintenance. A vehicle consuming 750 gallons of gasoline per year can save approximately $375 in fuel costs. The American Gas Association (AGA) has promoted the product in a coast-to-coast caravan of gas-powered vehicles using the ALCOA tanks. The inventor is now applying the same techniques to larger cylinders for use as gas transport trailers which will replace heavy, uneconomical steel cylinder trailers. Other applications for the technique will also be soon forthcoming.

o A closed-cycle dehumidification clothes dryer reduces energy uses by 65 percent over conventional dryers. DOE made a grant of $89,000 to the inventor to design, construct and test the clothes dryer. The inventor is currently planning to raise capital and market the product directly. This invention was highlighted in the November 1984 issue of "Venture" magazine.

o A microwave heating method was funded that replaces asphalt roads in-place, without the costly material handling operations that are required in the conventional method. DOE made a grant of $87,000 to test the microwave application and to design the prototype paving machine. The inventor is in the process of forming a business venture to manufacture and market the technology.

National Appropriate Technology Assistance Service ($1,000,000)

The goal of the National Appropriate Technology Assistance Service (NATAS) is to provide tailored information responses, engineering/scientific technical aid, and commercialization-technical information to anyone in the United States who needs to know more about those technologies that lend themselves to self-help and provide solutions to individual energy problems. These "appropriate" technologies usually rely on sun, wind, and water resources and energy and natural resource conservation methods and devices.

The program is most beneficial to small businesses, farmers, homeowners, state and local governments, and nonprofit organizations. NATAS is working closely with existing Federal, state, and local programs coordinating technical assistance activities.

Energy Conversion and Utilization Technologies $20,700,000

This request is to provide funds to expand the technology base for the conservation program. Funding of $20,040,000 is requested for the following research areas: Combustion and Thermal Sciences, Materials, Biocatalysis, and Tribology, along with $660,000 for program direction and International Research Monitoring.

Combustion and Thermal Sciences .... $ 6,470,000

Combustion Technology Research ($5,000,000)

The objective of the Combustion Technology Research activity is to provide a set of proven analysis and measurement techniques and a better understanding of combustion and combustion-related processes for intermittent and continuous combustion systems and devices. The ECUT activities are structured to ensure the usefulness and availability of these capabilities to designers of engines in industry. Laser-based diagnostics and multidimensional computations are used to investigate pre-combustion fluid motion, fuel preparation, sprays and turbulence in combustion, and emission formation mechanisms. Research groups, which include DOE national laboratory and industrial researchers, convene periodically to study specific combustion-related problems in engines as well as stationary combustors. Experiments are designed to bridge the gap between hardware development and fundamental research. In addition, investigations of innovative combustion system concepts are conducted, e.g. pulse combustion systems with multi-fuel capability and systems that employ catalytic combustion.

The FY 1986 funding includes resources to continue activities in Engine Combustion Technology and in Continuous Combustion Technology projects. Through close interaction with industry, ECUT focuses research which has been identified as essential to the development and improvement of advanced engine concepts. These concepts are devised to improve fuel economy and enhance the ability of internal combustion engines to use alternative fuels without compromise of established emission requirements. The engine-related research will continue to focus on the investigation of: (1) events that are believed to promote the occurence of engine "knock" in dilute homogeneous-charge and direct injection stratified-charge engines. Engine "knock" limits an increase in compression ratio that can improve thermal efficiency of an engine and thus decrease fuel consumption; (2) fluid mechanics/combustion interactions in internal combustion engines with particular emphasis on the impact of turbulence on the combustion process; and (3) the role of sprays in diesel engine combustion with special emphasis on mixing rate of the charge (air and fuel) and soot formation and emissions. Research, to ascertain the role of fuel droplets on combustion as fuel properties and injection parameters are varied, will be used to evaluate the the suitability of alternative fuels-use in various engine concepts. In addition, this research will provide insight into the flexibility of multi-fuel use in such innovative concepts as pulsed-combustors.

Efforts will continue in the study of in-cylinder heat transfer and the effects of alternative fuels on the engine ignition process. Heat losses generally account for an estimated 60 percent of the difference between ideal fuel-air cycle efficiency and indicated efficiency which translate to a 5 percent reduction of engine efficiency due to heat losses. Understanding the relationship of the various processes of heat transfer in engines will lead to a reduction of this heat loss quantity. Approximately 3 percent efficiency gain appears attainable.

The continuous, or stationary, combustion research will be continued in the area of pulsed-combustion, and in understanding the effects of structure and physical properties of fuels on combustion. Pulse combustion is a process by which combustion of fuels is driven by self-sustained oscillations. Pulse combustors have been built in a variety of sizes and shapes and have been fired with oil, gas and coal. However, acceptance and development of pulse combustion systems have been hindered by high noise levels and the complex underlying theory of their operation. Small changes in configuration have significant effects on performance. To date, designs evolved more by trial and error and from empirical correlations than from the application of basic principles. The high combustion intensity, minimal standby losses, and potential for superior heat transfer make pulse combustion a very desirable technology. The ECUT program employs laser diagnostics and visualization techniques to develop an understanding of the effects of various operating parameters on performance and emissions of pulse combustion. FY 1986 efforts will investigate the effect of liquid and solid fuels on the operating parameters and therefore on the performance and emissions of pulse combustion. To date, most research on pulse combustion has been limited to gas as a fuel.

In the combustion of fuel-oil sprays, the liquid fuel drops change into carbonaceous porous sphere-like particles called cenospheres. These cenospheres burn and the products determine the majority of the deposits found on metal surfaces, promoting corrosion/erosion. Trace compounds existing in the initial fuel drop have a much higher concentration in the cenosphere than in the original fuel. Therefore, work will be continued toward the development of a dense spray computer model which will include the formation and subsequent combustion of the cenosphere. This effort will include the investigation of the role of fluid mechanics in spray evolution and subsequent combustion. The results are essential to the understanding of single- and multi-component fuels combustion and the relevance to combustion of alternative fuels.

The technology-base development of micro-emulsion fuels will also continue. These fuels, which have very small droplets, usually 2 to 100 nanometers diameter, of an aqueous phase in a base fuel, provide a method for altering fuel combustion properties.

Understanding the combustion and related processes of fuel sprays is essential in the development of alternative fuels likely to be used in place of refined grades of petroleum-based fuels; the successful development of methods that provide for the tailoring of alternative fuels enhances the acceptability of alternative fuels to a range of applications.

Thermal Sciences ($1,470,000)

The objective of the Thermal Sciences activity is to provide a comprehensive technology data base for use by industry to design and further the development of conversion systems and devices with enhanced performance and reliability over those currently available. Applied and exploratory research is undertaken to strengthen experimentally validated analysis and computerized data bases necessary to strengthen the private sector's design and development abilities. Results include validated prediction capabilities, innovative energy conversion concepts, and improved understanding of the thermodynamics, heat and mass transfer, and fluid mechanics of processes involved in energy conversion.Deficiencies in both theory and in practice are examined to identify and prescribe solutions for loss mechanisms that contribute to efficiency and reliability limits of advanced energy conversion systems and devices.

FY 1986 research activity will continue to serve as the focus for the applied research and exploratory development needs of advanced conversion system development. A comprehensive experimental program, initiated in FY 1985 to exploit the capabilities of the Reversing Flow Test Facility, will be continued to study fluid dynamics in major components under development for closed-cycle systems and to validate analysis methodologies, currently being developed. In FY 1985, research was initiated to investigate the aspects of regenerator theory as it relates to performance for real systems. This effort is undertaken to examine flow maldistribution problems apparent in Stirling engine regenerator designs. It is believed that these maldistribution problems contribute to heat conduction losses, resulting in low efficiency operation. In addition, there continues to exist unexplained differences between theory and actual practice which are believed to contribute significantly to heat transfer-related inefficiencies evident in energy conversion systems. These differences are believed to be due primarily to inaccurate estimations of pressure drop for flows through complex channels and a lack of adequate understanding of actual flow conditions, i.e. steady vs. unsteady flow conditions. The continuing research focuses on the identification of controlling mechanisms in regenerator flows, with an objective to establish specific guidance for regenerator design.

FY 1986 activities will also include the continuation of work in the development of improved general purpose analytical computer models for use in the design of advanced energy conversion systems that employ such closed-cycle designs as free piston and the kinematic Stirling engine system.

The ECUT mission includes the examination of innovative concepts and ideas that, when deemed feasible, will improve on the existing technology base as well as introduce new, advanced options. The ECUT direct contact heat exchanger research is a continuation of activities initiated in FY 1983. Work is currently underway to research an innovative concept for direct contact of gas and fine solids which would render significant energy savings in the Industrial sector. Research is focused to develop experimentally validated mathematical models that provide better understanding of heat and mass transfer involved when two media are in direct physical contact, and to investigate the technical feasibility of innovative direct contact heat transfer concepts. Activities lead to the development of an improved technical approach to designing direct contact heat exchangers for specific energy conservation applications.

In addition, a preliminary investigation will be conducted to determine the specific research needs for the development of direct conversion technology. Today's energy conversion systems are technology limited which precludes full conversion of the available energy to usable form. Successful development of direct conversion devices will provide a topping system capable of converting a major portion of the unused available energy characteristic of today's energy conversion systems. This activity will continue to include such technologies as thermoelectrics, alkali-metal devices, ferromagnetic devices, and other innovative concepts.

Materials $6,000,000

The FY 1986 request for the ECUT Materials Project is $6,000,000. The ECUT Materials Project seeks to identify and develop new materials and processing concepts of potential use to energy conservation. ECUT monitors and picks up on the wealth of research opportunities coming out of basic research programs particularly those funded by the DOE Division of Basic Materials Sciences and the National Science Foundation; ECUT develops sufficient data on the properties and performance characteristics of these materials and processing concepts and conducts research to improve them to the point that either an end-use program or industrial firm will undertake engineering development or make use of the new material in its components, devices or systems. Finally, ECUT enlarges the technology base underlying the engineering of materials by providing predictive models for the use of design engineers.

This level of FY 1986 funding is necessary to continue research in the areas of high temperature materials, materials-by-design, and lightweight materials.

High-Temperature Materials ($3,500,000) ECUT high-temperature materials research currently underway will be continuedin FY 1986 for the following:

- Ductile Ordered Metallic Alloys
- Ceramic Attachments
- Physical Chemistry of Ceramic Materials

Ductile Ordered Metallic Alloys: Metallic materials with ordered atomicstructures such as Long-Range Ordered (LRO) and Intermetallic alloys havenot been utilized until now despite their potential for superior performance(e.g., four times the yield strength of conventional "superalloys" at elevatedtemperatures) due to their characteristic brittleness. These high-temperaturematerials have the unusual property of increasing in strength with increasingtemperature and can withstand other severe operating conditions such as corrosive environments.

An advantage that these metals have over superalloys is that they contain nocobalt or chromium which are critical/strategic elements. ECUT research isfocused on the initial measurement and improvement of engineering properties(yield strength, ductility, creep, fracture toughness, etc.) of the type neededby designers of future high-performance energy conservation concepts and ondelineating the limits of improvability of those properties.

In early 1982, after more than 30 years of failure by numerous researchers, a breakthrough was achieved at Oak Ridge National Laboratory in the ability to make one member of the intermetallic compound family, nickel aluminide (Ni_3Al), highly ductile (on the order of 50%). True to its mission, ECUT immediately provided the major funding necessary to capitalize on this basic research breakthrough and began to support the characterization and improvement of this material. This research will continue in FY 1986. To date more than 200 inquiries have been received from industrial firms concerning this work on ductile intermetallic alloys. A technology transfer workshop on these new classes of materials, ductile intermetallics and long-range ordered alloys, is sponsored annually by ECUT for the benefit of U.S. metals producers and potential users.

Like the LRO alloys, the ordered intermetallics increase in strength with increasing temperature. Presently this yield strength increases up to a certain point and then begins a gradual decline. However, no reason has beenfound yet why this strength should not continue to increase right up to the decomposition temperature which far exceeds 1000°C. In FY 1986 ECUT will continue research toward understanding this mechanism of increased temperature stability in nickel aluminide and applying this knowledge to make other members of the intermetallic compounds highly ductile such as aluminides of titanium, iron and magnesium, to name just a very few.

Ceramic Attachments: ECUT ceramic joining work seeks to ensure the availability of methods to join ceramic components together whenever they can be manufactured. Such techniques are important because they will allow ceramic components to be used economically in large operational systems such as heat engines and heat exchangers.

ECUT research aims to increase the understanding of the problems and limitations inherent in joining and bonding ceramics to ceramics and ceramics to metals. In FY 1985 development of predictive models for five typical attachments and concurrent experimental testing to verify the prediction wereunderway. The FY 1985 ECUT research concentrated on showing the feasibility of joining ceramic materials with and without brazes by means of radio frequency radiation; the work to model interfacial stresses in the joint region of five basic geometries was begun. In FY 1986, these joining experiments and verification of the predictive models for both brazed and unbrazed joints for the five basic geometries will be continued. Work begun in FY 1985 to understand and model interfacial phenomena important in ceramic attachment alsowill be continued.

Physical Chemistry of Ceramic Materials: Ceramic materials fail catastrophically through the growth and propagation of defects, particularly cracks initiated at free surfaces. The principles behind methods of toughening are to reduce the size and numbers of defects and to provide in the ceramic matrix a secondary phase that can absorb the crack propagation energy and arrest it. In the case of transformation toughening, a minor phase absorbs the energy by undergoing a diffusionless phase transformation to a higher energy but nevertheless stable phase. In the case of compositing approaches, a minor phase such as a fiber with some ductility is provided to absorb the energy by elastic and plastic deformation.

ECUT has been investigating the reasons for the brittleness of these materialsand is researching methods to toughen them by compositing and modifying their surfaces by ion implantation and other techniques. In addition, novel synthetic routes to produce precursor materials which have surface energies favorable for forming strong chemical bonds are being explored in order to reduce the number and size of flaws in the first place.

In FY 1986 ECUT will continue to composite various ceramics with the LRO alloys and/or aluminide materials discussed above. These efforts could make fabrication of reliable, high-strength ceramic components possible. In addition, work begun in FY 1985 using ion implantation and lasers to modify ceramic surfaces to arrest surface initiated crack propagation will be continued in FY 1986.

Ceramics corrosion: Ceramics are generally thought of as being highly resistant to corrosion. However, at the very high operating temperatures expected of these materials in future energy systems, corrosion may be a major problem, especially if heavy metals such a vanadium are present in either the fuel or exhaust stream. ECUT will develop novel ceramics, glassy ceramics and make use of surface modification techniques such as ion implantation and laser implantation/annealing to reduce the susceptibility of ceramics to corrosion under conditions expected in future heat engine and heat recovery systems environments.

For all of this ongoing and proposed ceramics research, an effort has been made to avoid duplication of effort throughout DOE by coordination through the DOE Energy Materials Coordinating Committee, Subcommittee on Structural Ceramics, which has made a compilation and analysis of all structural ceramics research underway in FY 1985 in all DOE programs having structural ceramics research components. This analysis is available upon request and shows quite clearly the major areas of focus and complementarity of the various DOE programs. Avoidance of duplication with other agencies, such as DARPA, continues to occur by information exchanges such as those which take place at the Annual Interagency Coordination Meeting on Ceramics for Heat Engines.

Materials-By-Design ($1,500,000)

The present practice of energy conversion system designers is to select materials on the basis of their appropriate performance characteristics and cost. In general, materials are screened on a trial and error basis to see how well they perform in a component or system of interest (e.g., engine, heat exchanger, etc.). Although such testing will always be necessary, the selection of candidate materials on the basis of fundamental physical quantities common to all materials (e.g., the structure and bonding of the atoms or molecules in the material) is not done yet and could lead to the design of totally new and improved performance materials. In order to design materialsit is necessary to understand the relationship of the desired properties (e.g., ductility) and performance characteristics (e.g., high temperature survivability) to the structure and bonding taking place in the material. Given such understanding, a hierarchy of structural and bonding models can be constructed to predict the performance to be expected of any given assembly of atoms or molecules.

One area where such a materials-by-design approach may be helpful is in the selection and development of high-temperature alloys and coatings.

This initiative was begun in FY 1985 to apply to materials design problems a combination of the unique experimental and theoretical tools made available by the Federal Government at the DOE National Laboratories through the DOE Office of Basic Energy Sciences. These tools are being applied in a concerted research program to determine the relationship of bonding and structure at the atomic level to several materials related problems but especially those taking place at interfaces; e.g., adhesion of coatings to their substrates, catalytic mechanisms, grain boundary bonding in intermetallic compounds and bond energies at tribological surfaces.

In FY 1985 studies were initiated to determine the magnitude of the benefits(including energy savings) of being able to design materials to specification. In FY 1986 research will be continued in the area of interest selected for initial study, viz. metal clusters as a model for grain boundary adhesion inductile intermetallic alloys.

Lightweight Materials ($1,000,000)

ECUT research on lightweight materials is being carried out in the following areas:

- Decomposition and reuse of plastics
- Corrosion-resistant magnesium alloys
- Reactive polymeric processing
- Surface modifications and coatings to impart improved corrosion protection

Decomposition and Reuse of Plastics: Successful research on ways to reuse post consumer plastics will permit the economical recovery of large (one quad and growing) quantities of high-energy content materials which presently end up in land fills. The amount of petroleum-based feedstocks necessary for increasing production of plastics and other polymeric materials would be reduced and a disposal problem would be lessened. Over a billion pounds per year of plastics are used today in automobiles alone, and this use is growing. Presently, these plastics from scrapped autos are thrown away. The capability to recycle these materials may make them more acceptable to auto manufacturers for major structural parts such as fenders and hoods thus reducing the weight of the vehicle and saving more energy while enhancing the environment. Automotive and structural plastics (high and low density polyethylene, polyvinyl chloride, polypropylene and polystyrene and polyurethane) were chosen as target materials because of their large and increasing volume of usage.

In FY 1984, the so-called "as is" plastics recycling work was initiated by ECUT three years ago with the Plastics Institute of America. Mixtures of plastic shreds from junked automobiles were combined with materials called "solid phase dispersants" or "compatibilizers" and then remolded directly. This project was transferred to the DOE Office of Industrial Programs for further development. ECUT research had discovered compatibilizers which made this direct remolding approach feasible.

In FY 1985 a competitive solicitation (RON) was issued seeking ideas on the much more difficult but potentially higher long term pay off approach to plastics recycling of decomposing the polymeric chains themselves into smaller molecules which could then be made into new products. Thermal decomposition was the first depolymerization route to be tried and the RON was issued for this approach. An RFP follow-on to the RON solicitation will be issued in FY 1986 and actual research will be begun from proposals selected from this RFP.

Corrosion Resistant Magnesium Alloys: The availability and use of strong, lightweight, corrosion-resistant structural materials would lead to major savings in the energy embodied in these materials because of the increased useful life of the product. ECUT will build upon the results of the basic research being carried out on the mechanisms of corrosion in the DOE Energy Storage Program (Energy and Water Appropriation) to investigate means of developing strong, corrosion resistant, lightweight structural materials.

Magnesium, a metal which per unit volume is only two thirds as heavy as aluminum, is readily available from seawater and from abundant domestically available magnesium ores. However, some applications of magnesium are excluded because it corrodes readily. ECUT research is focusing on novel alloying and coating approaches to lower the electrochemical reactivity and improve thecorrosion resistance of magnesium.

The availability of corrosion resistant magnesium alloys for structural uses in transportation would conserve premium petroleum fuels in proportion to the reduction in the weight of a vehicle.

In FY 1985 work was begun to make small samples of selected alloys from the family of magnesium aluminide intermetallic compounds which are expected to afford the best corrosion protection. This work will be continued in FY 1986. In addition, research initiated in FY 1985 on the corrosion protection imparted by surface modification techniques such as ion implantation and laser annealing will be continued in FY 1986.

Reactive polymer processing : In FY 1986 ECUT will explore the feasibility of using the heat generated in the polymerization process to reduce energy consumption in the plastic molding process.

Catalysis/Biocatalysis $3,285,000

The FY 1986 request for the ECUT Biocatalysis Research Project is $3,285,000. This level of funding is necessary to continue research already underway in bioprocess engineering and to undertake research and planning in catalysis-by-design and biologically effected separations/beneficiation.

A recent (January 1984) Office of Technology Assessment report entitled: COMMERCIAL BIOTECHNOLOGY, An International Analysis , stated in the foreword..."although the United States is currently the world leader in bothbasic science and commercial development of biotechnology, continuation of theinitial preeminence of American companies in the commercialization of biotechnology is not assured...In the next decade, competitive advantage in areas related to biotechnology may depend as much on developments in bioprocess engineering as on innovations in genetics...and other areas of basic science." The OTA report essentially identified bioprocess engineering applied research as the weakest link in the U.S. biotechnology research effort. It is exactly this area, bioprocess engineering, on which the ECUT Biocatalysis Research Project has been focusing its efforts.

Bioprocess Engineering ($2,285,000)

The ECUT program seeks to put the design and scale up of biochemical production processes on a rational basis. This means that ECUT develops kinetic expressions, rate constants, heat and mass transfer equations and other data and models needed by biochemical process engineers to design and scale-up production processes. The goal is to establish an engineering technology base for biochemical production of industrial chemicals analogous to that which exists today for conventional chemical processes.

With the advent of recombinant DNA techniques for engineering specific capabilities into microorganisms, it became possible in principle to produce enzymatic materials on demand for carrying out specific chemical reactions. ECUT focuses on resolving major generic technical barriers that impede the use of genetically-engineered microorganisms to carry out biologically catalyzed (biocatalyzed) continuous chemical production processes. Such processes have the potential to save process energy not only because of the ability of biocatalysts to carry out exactly the desired chemical reaction in one step (thereby avoiding large energy inputs for intermediate product purification and separation) and at the mild reaction conditions prevailing in biocatalyzedreactions but also to make use of renewable or more abundant feedstock than conventional chemical processes.

A typical problem being researched is the stablization in genetically engineered microorganisms of the genetic information which has been inserted to make the organism produce desired chemicals. Usually some of this information is lost each time the microorganism divides. While this loss of genetic information is not a great problem in bench scale (1 cubic meter size) fermenters, it can be a major problem for industrial scale (1000 cubic metersize) continuous processes where the microorganisms reproduce millions of times, perhaps to the point where in a very short time none of the useful genetically engineered microorganisms are left. This is just one example of the problems encountered by biochemical engineers who want to design and scaleup biocatalyzed production processes. In FY 1986, at this funding level, work begun in FY 1986 from a competitive research solicitation (RFP) for novel ideas on bioreactor designs for biocatalyzed chemical reaction processes will be continued. In addition, planning of research will be initiated on the direct use of enzymes in biochemical reaction processes.

At present biocatalyzed reactions are carried out by the use of microorganisms. Inherent in such an approach is the expenditure of energy to keep the organisms alive as well as the synthesis of a wide variety of chemicals (obligatory for cellular metabolism). In the long-term, the exploration of the direct use of stabilized enzyme biocatalysts (instead of microorganisms) for discrete chemical transformations would have a profound influence on advancing biochemical process engineering.

Catalysis-by-Design ($500,000)

In FY 1985 planning was begun on catalyis by design viz. gaining a better understanding of the mechanisms of catalysis by studying biocatalyzed systems. Actual research will begin in FY 1986.

Many researchers believe that the fundamental mechanisms of catalysis will be elucidated by understanding how biocatalysts (enzymes) work. While the elucidation of these fundamental mechanisms is the province of basic research, there are some major bioengineering problems that need to be addressed, such as: a) slow rates, b) thermosensitivity, c) cofactor requirements, and d)immobilization of the biocatalyst without loss of catalytic activity.

What is proposed here is an integrated theoretical and experimental applied research program based on the results of mechanistic studies coming out of basic research to develop and verify a molecular level computer models for enzyme systems that would provide the basic data and understanding generic to the problems stated above. A complementary phase of such a research endeavor would be the development of molecular level reaction models for studying chemical catalysis. Together, these two models could be used to predict and develop optimal hybrid chemical/biological catalysts. The success of such an endeavor would require the collective efforts of quantum theoretical chemists, organic chemists, molecular geneticists, biochemical engineering and computer and information systems specialists. Such a coordinated research program would be unique, particularly in the field of biocatalysis.

The essential technical elements of such enzyme catalysis models would be the development of theoretical force fields that accurately and rapidly predict the forces (hence, the chemical activity) on all atoms of an enzyme-reactant system. Such information allows for a dynamic prediction and calculation of changes in the reacting enzyme at the atomic level as well as a graphics system that at each time step can zoom in on selected parts of the enzyme so as to follow the reaction as it proceeds. It is anticipated that initially these studies will be aimed at one or two representative enzyme systems whosechemistry and physics have been extensively studied by basic researchers.

Such theoretical modeling efforts (that have predictive value) coupled to an integrated experimental approach in molecular genetics (which can engineer unique biological enzyme systems) will be useful in designing new enzymes that are suitable in non-aqueous media as well as those catalyzing non-biological molecules.

Furthermore, this initiative will set up a data-base resource where the private sector will have both access and strong interactions. Such an end-user oriented capability will allow for possible future joint ventures with industry and hence establish a meaningful continuing transfer of research results to the end-user.

Biologically Effected Separations/Beneficiation ($500,000)

It has been known for some time, because of the concentrating effect of the "food chain" where higher animals eat lower biological species (e.g. plants) that biosystems can extract and concentrate specific substances or elements such as metals from rather dilute environments. In fact, biohydrometallurgy is a commercial process for the leaching of copper from low grade ore deposits. The potential advantage of such biobenefications lies in their ability to effect such separations and or concentration of desired materials by using renewable energy sources such as solar energy, (in the case of plants). In FY 1986, ECUT will initiate planning and research to use biological systems to separate or concentrate chemicals or metals from dilute solutions.

Tribology $3,285,000

The Research Committee on Tribology of the American Society of Mechanical Engineers (ASME) has determined that up to 11 percent of all the energy lost through friction, wear, and poor lubrication could be saved if these losses were reduced or eliminated. The ECUT Tribology program, therefore, examined nine sectors of the economy in more detail than the ASME and estimated that up to 0.15 quad could be saved in the aggregate in the mining, agricultural, foodprocessing, chemicals, pulp and paper, primary metals, and metalworking industries through better tribological components and systems; up to 0.5 quad could be saved in the utility sector; and up to 2.8 quads could be saved in the transportation sector. For these reasons, ECUT has designed a tribology program targeted at saving energy where the generic needs seem to be greatest.

This program aims to save energy by developing a better understanding of how lubricants work, by designing friction and wear tests and validating data, and by modifying tribological surfaces in order to reduce wear and to extend operating life. These research projects are subjected to frequent critical review by industrial users to insure that the base technology being developed by ECUT will be further implemented by end-use sector offices and by private industry itself.

Lubricants ($1,000,000)

For years the lubricant industry has been puzzled by the sometimes significantly different ways different lubricating base stock oils react to additives. The answer came through ECUT research, which has identified the compound in base stock oils that interacts with the lubricant additive. This research will assist industry in the development of new and improved lubricants and has opened up a new avenue in additive chemistry research. As the sources of crude oils that are suitable for base stock oil production become depleted, the importance of this research will increase over the coming years. A final report summarizing this information was published and circulated in FY 1985 where it generated much positive interest by industry. Research to be funded in FY 1986 will build on this knowledge in order to develop predictive theories relating the lubricant molecular structure to effective control of friction and wear. Efforts will begin that are aimed at carefully defining the precise tribological conditions existing in machine elements, such as bearings, gears, and engine components.

Also in FY 1985 a final report on high-temperature lubrication needs for advanced heat engines was used to develop a comprehensive program plan for this area of research. A companion study for advanced tribological systems (except heat engines) will be conducted in FY 1986. Based on these findings, initial investigations of lubricants and lubricating concepts for use in advanced heat engine environments at temperatures up to 600°C will proceed. The research on low-temperature effects of molecular structure will be applied to this research, and new compounds will be synthesized and systematically tested. Close coordination with the DOE/Office of Transportation Systems, the Department of Defense, and the National Aeronautics and Space Administration will continue in this area.

Mechanisms of Friction and Wear ($800,000)

For the past 2-3 years the ECUT Tribology program has been the major Government-financed supporter of ceramic friction and wear studies in the United States and is currently leading all other Government programs in the magnitude of funding and in impact of results. The Office of Transportation Systems has utilized the initial tribological analysis and exploratory tests conducted in the ECUT program to determine the performance of available ceramics in simulated advanced diesel engine environments. ECUT, therefore, will now emphasize understanding the mechanisms of friction and wear of materials, including ceramics.

FY 1985 research on in-depth analysis of effects associated with the unlubricated sliding of a few well-characterized model ceramics defined the"low-wear" region as a function of temperature (up to 650^{o}C), load, andvelocity. Specimens were analyzed to understand the microstructural, thermomechanical, and thermochemical effects. In FY 1986 these studies will be extended to consider the effects of environment. Additionally, the focus of the work will shift to lubricated unidirectional sliding and will take advantage of the research conducted in the lubrication portion of the Tribology program. Of the ceramics materials to be studied, particular emphasis will be placed on friction and wear testing of novel ceramics, new ceramic concepts, and surface-modified ceramics in order to anticipate future needs of the Office of Transportation Systems.

Friction and Wear Testing ($500,000)

Preparatory to beginning a new research thrust in FY 1986, an assessment was conducted in FY 1985 to determine how applicable present-day testing procedures are to ceramics. The results of the assessment indicated that new avenues of research are possible and that not all tests for metals can be used effectively for ceramics. For these reasons, the ECUT Tribology Program will coordinate with the American Society for Testing and Materials (ASTM), the ASME, and others to intitate a program in developing meaningful standardized friction and wear tests for ceramic materials. Test rigs and analytical equipment will be used to develop tests that can be certified by standards and professional organizations. The initiation of this work will be announced at a major international symposium on ceramic friction and wear sponsored by ECUT in FY1986.

Some testing, however, will continue on dissimilar ceramic pairs in order to understand better the properties of these materials under the temperature and stress regimes of the adiabatic diesel engine. ECUT's research will provide the Office of Transportation Systems with a validated methodology and data that will be needed in their adiabatic diesel program. Procurements in testing research will be by means of an interagency agreement with the National Bureau of Standards and cooperative agreements with ASTM, ASME, and others in industry.

Tribological Coatings ($985,000)

What can be gained by surface modification research for tribological applications is increased energy savings and productivity because a treated surface can be made harder and more durable than the untreated material. Surface modification research, which increased substantially in FY 1985, began developing theoretical models based on solubility criteria and then began testing and validating them. Analysis and testing of coatings other than titanium nitride will be performed in FY 1986. Exploratory research on two-stage surface/material modification (ion implantation of the work piece to improve its chemical and physical properties for subsequent ion plating to produce overlayers) will continue in order to produce tribological surfaces that exhibit low wear, low coefficient of friction, high corrosion resistance, or other desirable characteristics. These surfaces could be bearings, cutting tools, gears, farm implements, and the like. Interaction and participation with an industrial-university-national laboratory working group will continue.

The next step in this research approach will be to explore a three-stage process of work-piece preparation (ion implantation), overlayer production (ion plating), and overlayer modifications (ion doping or laser beam or electronbeam glazing) of the surface/substrate. This process should offer superior tribological protection compared to a single-step process. Improved techniques to characterize these surfaces will be developed along with advanced testing techniques. It will be necessary to use cutting edge diagnostic tools such as synchrotron radiation spectroscopy for this research. The consortium of researchers mentioned above will be broadened in FY 1986 to include additional members who will be competitively solicited.

Results gained from tribological surface modification research in FY 1985 willhave laid the foundation for a transportation-related thrust in FY 1986. Surface modification techniques will begin to apply the theoretical tools developed in the cutting tool research to the more technically difficult area of the piston ring-cylinder liner interface. This is an area where generic research..from one field (cutting tools) can be used in another (transportation).

International Research Monitoring $150,000

ECUT is also responsible for evaluating and comparing the current status and projected directions of energy end-use and energy conversion technologies funded by foreign nations. This is an important new responsibility. When carried out, it will aid considerably in guiding research in DOE conservation toward developing more fruitful and energy efficient technologies that ensure future U.S. international competitiveness.

Plant and Capital Equipment $1,000,000

This request for plant and capital equipment will continue the upgrading of outmoded and acquisition of new equipment for the ECUT program at the DOE national laboratories. State of the art equipment including: a multi-fuel combustor system (Combustion), materials processing, evaluating and testing equipment (Materials), fermentation and control instrumentation (Biocatalysis) and surface modification and friction testing apparatus (Tribology) will be acquired. Historically Black Colleges and Universities (HBCU's) conducting ECUT research will be provided appropriate equipment in order for them to become competitive with more heavily endowed colleges and universities, especially in the area of biocatalysis.

Program Direction $510,000

Funding will provide for 9 full-time equivalents (FTE's) to conduct the research described above for the ECUT program. The FY 1986 funding level reflects reductions of $25,000 and $8,000 for pay cut and for savings in accord with Section 2901 of the Deficit Reduction Act of 1984 (P.L. 98-369) respectively from the FY 1985 level, and the addition of three FTE's.

Energy-Related Inventions Program $5,000,000

The FY 1986 Departmental Request for Energy-Related Inventions is $5 million. The Department requests a level funding effort for ERIP in FY 1986 because of the program's demonstrated effectiveness in supporting and transferring new technologies to the private sector. The funding level requested will provide for both the evaluation of a number of inventions and support for inventors in FY 1986.

National Appropriate Technology Assistance Service $1,000,000

The FY 1986 Departmental Request for the National Appropriate Technology Assistance Service (NATAS) program is $1,000,000. The funding level will provide for the continuation of a program which is beneficial to small businesses, farmers, homeowners, state and local governments, and nonprofit organizations. NATAS will continue to work closely with existing Federal, State, and local programs.

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

MULTI-SECTOR
ENERGY CONVERSION AND UTILIZATION TECHNOLOGIES

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Combustion & Thermal Sciences	$5,500	$6,470
	Engine Combustion...$3,545	Engine Combustion...$4,000
	o Correlate temperature and species concentration with kinetic calculations in the end gases of a "knocking" homogeneous charge egine. The kinetic reactants of the fuel-air charge play a significant role in the promotion of knock. Research will lead to anti-knock formula. o Apply laser diagnostics to an operating engine to examine temperature and turbulence relative to knock limitations of current engine designs. o Explore emission diagnostics to obtain information on the combustion characteristics of dense spray flames. Research is focused on understanding the role of droplet spray evolution relative to emission formation in Diesel engines.	o Perform NO_x/particulate trade-off studies of operating diesel engine for engine design optimization of emission characteristics. o Make flame structure measurements within the burning spray of Diesel and DISC engines. Research will address the mechanism of fuel spray development within engine and how fuel injector design parameters affects fuel distribution patterns, droplet sizes, and injection rate. Effort will lead to optimization of fuel-air ratio and distribution at the point of injection. o Use laser velocimetry to analyze in-cylinder processes that govern engine performance such as mixing and combustion which are to a great extend controlled by turbulence and bulk fluid motion (swirl, squish). Specific swirl ports and cup-in-piston geometries will be studied. Important to the development of DISC engines.

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
	o Design and fabricate a new generation optical research engine to study the detailed combustion and emission formation characteristics of diesel sprays. Insitu measurements will be taken to examine the controlling processes of a Diesel engine. o Initiate research to study heat transfer processes in internal combustion engine environments. In-cylinder heat losses account for 5% reduction in engine efficiency. Research results will be used to improve efficiency by 3%. Initial effort will focus oon Diesel engine environment.	o Conduct in-cylinder research of convection and conduction heat transfer processes and couple with radiation effort to develop integrated experiment and analytical model incorporating all three heat transfer processes and accompanying impact on performance and realiability of such engines as the adiabatic Diesel as well as the open-chamber Diesel concept. o Continue research on role of fuel droplets on combustion as fuel properties and injection parameters are varied. Selected fuel samples will be used to represent variations in fuel properties and their impact on fuel spray development. Research will enhance the ability of DISC and diesel engine concepts to use low-grade fuels. Significant savings are realized at the refinery as well as via use of fuel efficient engine.
	Continuous Combustion ...$935	Continuous Combustion ...$1,000
	o Initiate study of multi-component fuels. Investigate effects of chemical structure and thermophysical properties of fuels. o Measure fluid dynamics and chemical processes of pulse combustor to determine the effect of mixing chamber configurrations.	o Investigate the effect of fluid mechanics on spray combustion. Extend non-dilute spray model to multicomponent fuels, including cenosphere formation and combustion. The processes of injection, vaporiza tion, mixing and combustion affect system performance as well as emission of pullutants such as soot and oxides of nitrogen. This research focuses on

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
	o Continue research for microemulsion fuels technology data base development. Employ small-angle neutron scattering in study of microemulsion fuel systems. Develop computer model.	improving the understanding of atomization and the temperature, pressure, oxygen mass fraction and flow velocities experienced by the fuel, for liquid-fueled systems. Current understanding of these controlling processes is inadequate for combustor designers to meet future needs. o Determine the effects of such operating parameters as fuel-air ratio, mass flow rates, and temperature and pressure on performance and emission characteristics for pulse combustion. Initiate work on liquid and solid fueled systems. o Continue the development of microemulsion fuels technology data base. Experimentally validate computer model for micro-emulsion fuel systems. Research will produce a technology data base suitable for use by developers of fuels and fuel additives, to tailor alternative fuels to meet requirements of given applications.
	Advanced Heat Transfer ...$370 o Complete initial research on technical feasibility of direct-contact heat exchangers. o Complete flow-induced vibration experiments using water.	Advanced Heat Transfer ...$525 o Continue research to study regenerator anomalies between theory and actual performance data. o Develop user-friendly computer code for design of heat exchangers without fluid elastic instabilities.

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
	o Continue research to study anomalies in regenerator theory and performance data. Advanced Conversion Technology...$650 o Conduct research to develop advanced analysis techniques and to generate process knowledge of the thermodynamics, heat, and mass transfer in advanced cycles, including direct conversion devices and closed-cycle devices. o Investigate new and innovative concept to effect isothermal compression process for power cycles.	o Continue research on direct contact heat exchanger concepts & Issue RFP. Advanced Conversion Technology...$945 o Continue fluid dynamics, thermodynamics, and heat transfer research using Reversing Flow Test Facility. o Continue development of isothermal compressor concept for power cycles. o Initiate direct conversion technology research to advance current state-of-art.
Materials	$4,832 High-Temperature Materials...$3,000 o Initiate experimental investigation of mechanism of increased temperature stability in nickel aluminide. o Initiate research to make ductile other members of intermetallic family having high-temperature stability potential (e.g., iron aluminides)	$6,000 High-Temperature Materials...$3,500 o Continue experimental investigation of mechanism of increased temperature stability in nickel aluminide. Initiate research on problems of weldability and hot formability. o Continue research to make ductile other members of intermetallic family having high-temperature stability potential (e.g., iron aluminides).

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
	o Initiate experiments using radio frequency radiation to join ceramic materials both with and without brazing materials. o Continue finite element modeling of ceramic joint interfacial stresses in 5 basic geometries.	o Continue experiments using radio frequency radiation to join ceramic materials both with and without brazing materials. o Initiate experimental verification of ceramic joining finite element interfacial stress models. o Initiate research on corrosion of ceramic materials in severe environments.
	Materials by Design ...$1,000 o Initiate research to correlate the bonding and structure of selected model systems using both experimental and theoretical computational tools in an effort to design desired properties into materials by knowledge of their structure and bonding.	Materials by Design ...$1,500 o Continue research to correlate the bonding and structure of selected model systems using both experimental and theoretical computational tools to design desired properties into materials by a knowledge of their structure and bonding. o Initiate study of bonding in metal clusters as a model for nickel aluminide so as to be able to predict what micro alloying techniques to use to make any given intermetallic compound ductile.
	Lightweight Materials ...$832 o Initiate experiments to depolymerize automotive plastic scrap to monomers.	Lightweight Materials ...$1,000 o Continue experiments selected from competitive solicitation to depolymerize automotive plastic scrap.

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
	o Initiate experiments to develop new and corrosion-resistant magnesium alloys. o Initiate research on ion implantation/laser annealed modified surfaces for corrosion protection of iron and magnesium based alloys.	o Continue experiments to develop new and corrosion-resistant magnesium alloys. o Continue research on ion implantation/laser annealed modified surfaces for corrosion protection of iron and magnesium based alloys. o Initiate research on use of heat of polymerization reactions (reactive polymer processing) to save energy in the molding process.
Catalysis/ Biocatalysis	$2,000 Bioprocess Engineering ...$1,800 o Continue research on stabilization of genetic information in recombinant microorganisms. o Initiate research on novel bioreactor concepts (RFP).	$3,285 Bioprocess Engineering ...$2,285 o Conclude research on stabilization of genetic information in recombinant microorganisms. o Continue research contracts from competitive solicitation on novel bioreactor concepts which may make it feasible to economically produce chemicals such as butanol biocatalytically. o Initiate planning for research on direct use of enzymes in biochemical reaction processes to eliminate energy used to maintain the metabolic processes of living microorganisms.

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
	Catalysis-by-design ...$200 o Initiate research planning on catalysis-by-design through experimental characterization and theoretical modeling of biocatalytic systems.	Catalysis-by-design ...$500 o Initiate research on catalysis-by-design through experimental characterization and theoretical modeling of biocatalytic systems. Biologically Effected Separation/Beneficiation...$500 o Initiate research to use biological systems to separate or concentrate chemicals or metals from dilute solutions.
Tribology	$2,700 Lubricants...$900 o Synthesize several analogs of base stock oil, and test for lubricity and oxidation resistance at temperatures up to 200°C. o Investigate opportunities for developing four-ball wear test for ceramic materials that predicts the performance of actual ceramics when interacting with base stock oil fractions. o Conduct research on lubricants for warm forming region for metals (200°-600°C.), a regime applicable also to the adiabatic diesel.	$3,285 Lubricants...$1,000 o Validate model that correlates molecular structure with lubricant qualities, and synthesize model compounds in order to determine the exact parameters that control friction and wear. o Begin research with Naval Research laboratory and others to study whether deuterated and/or siliconized lubricants are more effective in preventing or reducing friction and wear than present-day lubricants. o Continue research on lubricants for warm metal forming region. o Continue research on in-situ deposition from the gas phase as a novel lubricating mechanism for elevated (200°-600°) temperatures.

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
	o Initiate research on solid lubricants for environments above 200°C.	o Initiate major new research thrust to investigate how high-temperature (above 600°C) lubricants operate in extreme environments typical of the adiabatic diesel; coordinate work with DARPA, Transportation Systems, and NASA.
	Mechanisms of Friction and Wear...$600 o Expand characterization of wear traces to understand and explain mechanisms of friction and wear of monolithic ceramic materials. o Explore and develop new techniques for analyzing wear surfaces.	Mechanisms of Friction and Wear...$800 o Conduct in-depth characterization of wear traces in order to understand friction and wear of monolithic ceramics and ceramic coatings for use in high-temperature regimes; share research results with DARPA, Transportation Systems, and NASA.
	Friction and Wear Testing...$200 o Begin coordinated testing research with ASTM, SAE, and other professional organizations. o Begin assessment of applicability of metal testing techniques to ceramics.	Friction and Wear Testing...$500 o Develop two standardized friction and wear tests for approval by ASTM. o Develop new tests specific to ceramics.

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
	Tribological Coatings ...$700 o Initiate experiments to determine thermochemical criteria for tailoring coatings for selected substrates, such as high carbon steels.	Tribological Coatings ...$985 o Expand FY 1985 efforts, and initiate development of advanced tribological coatings where hardened surfaces are a requirement, such as in the agricultural, cutting tool, and transportation sectors.
	Data Retrieval System ...$100 o Establish a cost-shared tribological data retrieval system with ASME.	Data Retrieval System ...$0 o End ECUT funding for ASME cost shared activity.
	Tribological Energy Losses...$200 o Continue identification of tribological sinks in U.S. economy. o Conduct analysis of potential energy savings in the cutting tool industry, and examine transportation sector in greater depth.	Tribological Energy Losses...$0 o Eliminate activity.
ECUT Innovation Program	Innovation...$576 o Conduct one solicitation for novel energy conversion concepts.	Innovation...$0 o Eliminate Activity.

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
	o Conduct analyses, based on National Academy of Sciences report, on new ideas and where opportunities for new ideas should be explored.	
International Research Monitoring	Research Monitoring ...$0 o No request.	Research Monitoring ...$150 o Initiate compilation of data base on status of energy conservation related research in selected foreign countries (Japan, Germany, Sweden).
Capital Equipment	Capital Equipment ...$1,666 o Acquire state-of-art laboratory equipment for all ECUT programs. Provide apparatus to Historically Black Colleges and Universities to enhance ability to participate in ECUT research programs.	Capital Equipment ...$1,000 o Acquire new and updated laboratory apparatus including multifuel combustor system; materials processing/evaluating/testing equipment; fermentation control and instrumentation; analytical instrumentation; and surface modification and friction testing/equipment.
Program Direction	Program Direction...$292 o Provide 6 FTE'S to manage ECUT research.	Program Direction...$510 o Increase ECUT program management support to 9 FTE'S.

DEPARTMENT OF ENERGY

FY 1986 CONGRESSIONAL BUDGET REQUEST

KEY ACTIVITY SUMMARY

MULTI-SECTOR
ENERGY RELATED INVENTIONS PROGRAM

Key Activity	Estimated Activities During FY 1985	Planned Activities During FY 1986
Energy-Related Inventor's Program	ERIP...$4,900 o Hold 3 commercialization workshops for inventions. Co-sponsor six National Innovation workshops on licensing, business plans, financial alternatives, and other similar topics. Evaluate 2,000 inventions proposals; approve 40-50 for further development.	ERIP...$5,000 o Hold 4 commercialization planning workshops for inventors, prepare commercialization workshops for and related technical assistance information for inventors. Co-sponsor six National Innovations workshops on licensing, financial alternative, business planning and similar topics. Evaluate 2,400 invention proposals; recommend 60-65 for assistance and provide financial and/or technical business assistance to 40 inventors.

DEPARTMENT OF ENERGY
FY 1986 CONGRESSIONAL REQUEST
LEAD TABLE
ENERGY CONSERVATION
POLICY AND MANAGEMENT

Conservation and Renewable Energy
Energy Conservation - Operating Expenses
(Tabular dollars in thousands. Narrative material in whole dollars)

	FY 1984 Appropriation	FY 1985 Appropriation	FY 1986 Base	FY 1986 Request
Energy Conservation				
Policy & Management				
Operating Expenses - Total	$ 1,280	$ 1,727*	$ 1,727	$ 2,600
Total FTE's	27	24	24	17

Authorization: Section 209 P.L. 95-91, "Department of Energy Organization Act."

Summary of Changes

FY 1985 Conference Mark less 2901 rescission........................		$ 1,727
o Impact of 5 percent pay reduction..............	- 33	
o Section 2901 rescission.........................	- 20	
o Crosscutting contract support...................	+ 1,206	
o Reduction of 7 FTEs.............................	- 280	
		+ 873
FY 1986 Request...		$ 2,600

* Reflects savings of $20,000 for Section 2901 of the Deficit Reduction Act of 1984 (P.L. 98-369).

Budget Request: The Policy and Management FY 1986 request is $2,600,000 and 17 full time equivalent staff years of effort.

The FY 1986 request provides for overall management guidance to CE programs. Staffing levels provide the executive and overall program direction for all CE programs to ensure effective management. These activities include executive management, policy formulation, program review and approval, and liaison with senior officials in DOE, White House, Congressional, OMB, other Departmental Agencies, private industry, and State and local governments. In addition, the staff will carry out analyses of the CE programs needed to assess performance and effectiveness.

The FY 1986 request also provides for the support of functions such as planning, policy development and analysis, program planning and evaluation, budget preparation and execution, program and personnel management and administrative support performed by the Offices of the Assistant Secretary and Policy and Management. Activities performed include development of planning guidance, analysis of program options for achieving planned objectives, evaluation of performance against program objectives, handling and/or coordination of program/budget submissions and execution of approved budgets and ongoing support functions in the areas of: administrative services, procurement, personnel, space management and related support services including a comprehensive program review function. In addition, funds are included for the continuation of a procurement tracking system and an automated support system which provides text processing, electronic mail, data base management, communication and other program applications.

The following is a detailed breakdown of estimated costs required to provide for this support function:

	(in Thousands)
Personnel compensation	$ 588
Personnel benefits	62
Travel and transportation of persons	600
Other services	1,350
Total	$2,600